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FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVES: ATCHISON, TOPEKA & SANTA FE RY.

The Atchison, Topeka & Santa Fe Ry. has a number of locomotives of special and interesting design, some of which were described in our issue of April 24, 1902, and the latest of these special engines are the new compound passenger engines on the four-cylinder balanced system. This road already has four-cylinder compounds with superimposed and tandem cylinders, in both of which arrangements the power from each pair of cylinders is transmitted through a single crosshead and connecting rod. The new engines are a modification of the Von Borries type, in which four cylinders are arranged in a transverse row and are all connected to a single driving axle. The essential difference between this system and the more extensively used De Glehn system, is that in the latter the outside high-pressure cylinders drive one axle, while the inside low-pressure cylinders drive another axle, and four separate valve gears are used, as explained in another column. While the design of the new engines is in general similar to that of Mr. Von Borries (of the Prussian State Railways), it has been modified and simplified (especially in regard to the valves and valve gear) by the designer Mr. S. M. Vauclain, of the Baldwin Locomotive Works. The first American engine of this type was built in 1902 for the Plant Railway System (since absorbed by the Atlantic Coast Line Ry.), as noted in our issue of March 13, 1902, and a De Glehn four-cylinder engine has been built in France for the Pennsylvania R. R. In another column we have discussed the subject of four-cylinder compound locomotives.

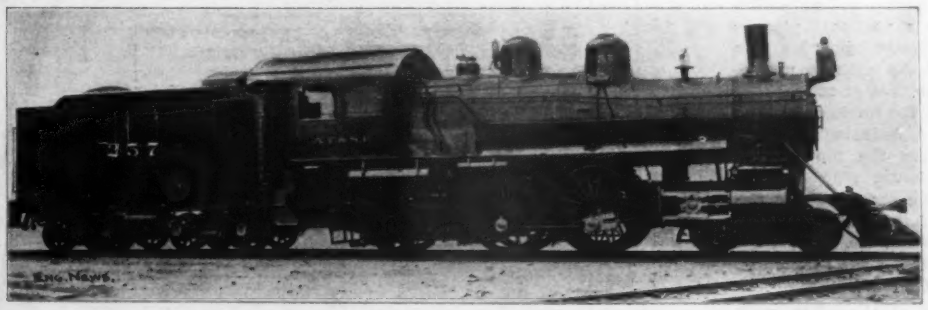

FIG. 1. FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE: ATCHISON, TOPEKA & SANTA FE RY.

S. M. Vauclain, Designer; Baldwin Locomotive Works, Philadelphia, Pa., Builders.

The new engines of the Atchison, Topeka & Santa Fe Ry., already referred to, are four in number, of the Atlantic (or 4-4-2) type, and are intended for fast running with heavy trains on divisions having moderate grades. From the view in Fig. 1, it will be seen that there is little in their general appearance to distinguish them from simple engines of the same type, except that the front drivers are the main drivers, this being, of course, necessitated by the connection of the inside cylinders to the driving axle. The main feature is in the arrangement of the cylinders, and this is shown in Fig. 2. The saddle is cast in two parts, each containing two cylinders and the valve chamber or steam chest which serves both of these cylinders. The center lines of the cylinders are all in the same horizontal plane, and the valve chamber is above and between its two cylinders, while the bar of the frame passes under and between the cylinders. It will be seen that the high-pressure cylinders are inside, although the general foreign practice is to put them outside. Live steam can be turned into the low-pressure cylinders for starting, as in other forms of four-cylinder compound locomotives.

The valves, Fig. 3, are of the piston type, 15¼ ins. diameter over the packing rings, before these are compressed to fit within the 15-in. chamber. The length of the valve is 33 ins. The middle head of the valve has inside admission to the high-pressure cylinder; each end head has outside admission to the low-pressure cylinder. The high-pressure exhaust passes through the valve to the low-pressure ports. The steam admission and exhaust ports in the saddle are both at the middle of the valve. The pistons of the two cylinders work in opposite directions, starting their strokes at opposite ends of the cylinders. Each valve, as already noted, controls the steam distribution to one pair of cylinders, and each is operated by an ordinary Stephenson link-valve motion, with two 17½-in. eccentrics to the link. The links are of 45 ins. radius, with a slot 3¼ × 20¼ ins. They are hung between the driving axles, and driven from the eccentrics on the rear driving axle. The link block is carried by a vertical lever, the top of which is on a level with the valve rod, and from this a horizontal rod extends to the arm on the rock shaft, which has both its arms above the shaft. The movement of the reversing shaft is equalized by connecting an arm upon it to the middle of a horizontal transverse plate spring.

The next important point of special design is the crank shaft, and this is shown in Fig. 4. The use of crank shafts has always been objected to by both builders and locomotive superintendents in this country, but in view of the long and satisfactory experience with such axles on foreign railways it does not seem that the objections can be very serious. These particular shafts are of open-hearth steel, and the builders are experimenting with nickel steel with a view to its use for this purpose in the future. The character of the axle steel is shown by the following record of chemical and physical tests made by R. W. Hunt & Co., of Chicago:

Crank axles: open-hearth steel. Elastic limit, 16.07 tons per sq. in.; tensile strength, 31.42 tons per sq. in.; elongation, 25% in 3 ins.; reduction of area, 35.8%. Fracture, fibrous. Bend and drift tests, good. Chemical analysis: carbon, 0.345%; phosphorus, 0.029%; manganese, 0.700%; sulphur, 0.012%, arsenic, 0.018%.

The inside cranks are set at 90° and the inside and outside cranks of each pair of cylinders are at 180°. The shaft and the crank pins are 10 ins. diameter, which is considerably larger than the axles of many European engines of the same type. The rear driving axle is 9⅛ ins. diameter, with bearings 9 × 12½ ins. The construction of the cast-steel driving boxes is shown in Fig. 5. The guides are of the two-bar pattern, with alligator crossheads; and all the connecting and coupling rods are of I-section. The connecting rods are all 3½ ins. wide with a ½-in. web, the inside rods being 4½ to 6 ins. deep, and the outside rods 4½ to 5½ ins. deep; the flanges are uniformly 1 in. thick. The coupling rods are 3 × 4 ins., with a ½-in. web and ⅞-in. flanges. The frame is of cast steel, in two parts. The front portion is a single bar extending from the bumper beam to the front driving axle, where it is bolted between the jaws of the rear part of the frame, in which are formed the pedestals for the two driving axles and the trailing axle. Behind the second driving axle the top rail is dropped 14⅛ ins. to receive the firebox. In accordance with general practice in heavy engines, the use of longitudinal bolts through the pedestals, under the driving boxes, is dispensed with, and instead the feet of the pedestals are fitted into slots in heavy bars which are secured to the lower rail of the frame by vertical bolts. This makes a much more rigid and substantial connection. It will be noted that the ordinary style of frame is used throughout, while in many engines of the Atlantic type (including

those of the Wabash Ry., described in our issue of March 17, 1904, the bar frame extends only just beyond the rear driving axle, and a plate or slab frame extends to the rear of the engine and has the pedestals for the trailing wheels.

enabled to give the following particulars from a record of a run made with one of these engines on Feb. 19, 1904, with a Raymond-Whitcomb special excursion train. This was an ordinary service run and not an official test.

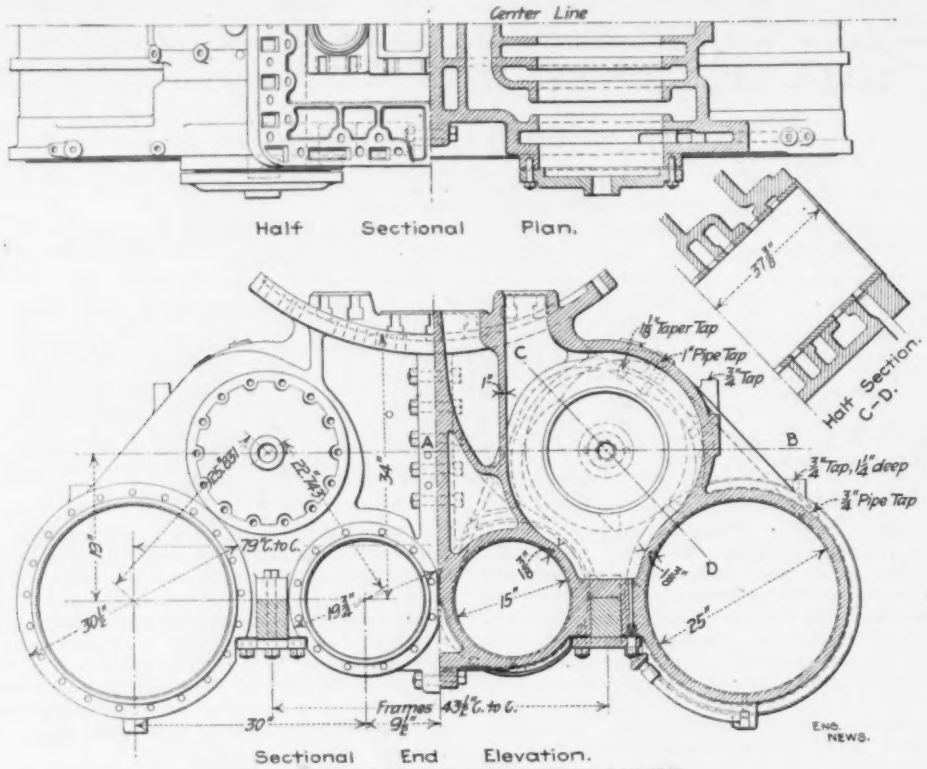

FIG. 2. CROSS-SECTION OF CYLINDER SADDLE.

The boiler is of the extended wagon-top type, 66 ins. outside diameter at the smokebox end, and 77 ins. at the dome. The firebox is wide, resting upon the frames, and has the crown sheet supported by crown stays on sling stays, as shown in Fig. 6. The front water leg is inclined, and the boiler is made with an inclined back head, as is now the very general practice, in order to cut down weight where long fireboxes are used. The front end arrangement is shown in Fig. 7 and is somewhat peculiar. The exhaust nozzle is fitted with a thimble, as shown in detail in Fig. 8, and the top of this is 3 ins. below the center line of the boiler. Directly over the nozzle and extending to within 1 in. of its top is a petticoat pipe or draft pipe, supported from below by angle iron legs resting on the flange of the exhaust nozzle, and from above by angle irons riveted to a throat piece which forms the base of the smokestack and extends into the smokebox. A deflector of No. 8 sheet iron extends from above the top row of tubes to and beyond the exhaust pipe, and its end is fitted with an adjustable apron. From the front end of the fixed part of the deflector plate an inclined screen of wire netting, No. 8 wire, 2 × 2 ins. mesh, extends to the front of the smokebox, and is attached to an angle-iron frame.

The driving wheels have cast-steel centers, with small counterweights in the rim arranged to fully balance the revolving parts. The counterweight in the main driver is on the same side of the hub as the crank pin, while that in the rear driver is on the opposite side to the crank pin. The spring rigging is equalized over the driving and trailing axles. Plate springs are set over the driving boxes, and a yoke is set over the trailing axle box; the front end of this yoke is connected to an equalizer and the rear end to an inverted plate spring seated under the top rail of the frame. The long equalizer between the trailing and rear driving axles also has an inverted plate spring, which is seated under the bottom rail of the frame.

The tender has a steel frame and a deep tank of 8,400 gallons capacity. It is mounted on a pair of trucks with diamond or arch-bar frames having wheels 34¼ ins. diameter, and journals 5½ × 10 ins.

Through the courtesy of the builders we are

Run	Dodge City to La Junta, Colo.; 202.4 miles.
Train—9 Pullman cars; weight	562 tons.
Time on road	4 hrs. 26 mins.
Delayed time (taking water)	0 " 14 "
Actual running time	4 " 12 "
Average speed, start to stop	45.0 miles per hr.
Average speed, deducting stops	48.2 miles per hr.
Water consumed	14,600 gallons, or 121,600 lbs.
Water evaporated per lb of coal	7.15 "
Coal per 1,000 ton-miles*	113.20 "
Steam pressure, regular	220.0 "
Grade	Level to 34 ft. per mile (0.64%)
Elevation	1,450 ft. in 202.4 miles.
Weather:	Foggy and bad, frosty rail for 50 miles, and heavy wind for last 30 miles.

*Including weight of tender.

The dimensions of these interesting balanced compound locomotives are given below in our standard tabular form.

Four-cylinder Balanced Compound Locomotive; Atchison, Topeka & Santa Fe Ry.

RUNNING GEAR:	
Driving wheels, (4); diameter	6 ft. 1 in.
Truck wheels (4); diameter	2 ft. 10 ins.
Trailing wheels (2), diameter	3 " "
Tender wheels (8), diameter	2 " 7½ "
Driving wheel centers	Cast steel.
Truck and tender wheels	Steel.
Driving wheel tires secured	By shrinking and [illegible].
Engine truck	Swing [illegible].
Journals, driving axles	10 × 11 ins. and 9 × 11 ins.
WHEELBASE: Driving	6 ft. 7 ins.
Truck	6 " "
Total engine	20 " "
Engine and tender	58 " "
Truck-pin to c. of driving axle	11 " 2 "
WEIGHT IN WORKING ORDER:	
On driving wheels	101,4[illegible] lbs.
On truck wheels	40,[illegible] "
On trailing wheels	42,[illegible] "
Engine, total	183,[illegible] "
Tender loaded	134,[illegible] "
Weight of piston and rod, h.-p. 260 lbs.; l.-p. [illegible]	"
Weight of crosshead, 298 lbs.; side rod [illegible]	"
Weight connecting rod, inside, 532 lbs.; outside 640	"
CYLINDERS: Number	Four
Diameter and stroke, h. p. 15 × 26 ins.; l.-p. 25 × 26 ins.	
Ratio of area of h.-p. to l.-p. piston	1 to 2.77
Cross head and guides	Two-bar; alligator
Connecting rod, length from c. of wrist pin:	
Inside 6 ft. 3½ ins.; outside	6 ft. 5 ins.
VALVE GEAR: Type	Stephenson link
Ports, steam and exhaust	34 × 1[illegible] ins.
Bridges, width	2[illegible] and 1[illegible]"
Eccentrics, throw	5[illegible]"
Piston valves, maximum travel	5 "
Inside lap (negative) h. p. ¼-in.; l. p. [illegible]-in.	
Outside lap " 1-in.; " none.	
Lead " None; " ⅛-in.	
BOILER: Type	Extended wagon-top
Barrel, diameter inside smallest ring	5 ft. 6 ins.
Dome, diameter	2 " 7½"
Barrel plates	11-16 & 13-16-in.
Smokebox tube-plate	½-in.
Horizontal seams, butt joints	Sextuple riveted
Length of smokebox (including extension)	4 ft. 9½ ins.
Injectors (2)	Ohio, lever movement, No. 10½
Working steam pressure	220 lbs.
FIREBOX: Type	Crown-bar stayed
Length inside, 8 ft. 11 15-16 ins.; width inside, 5 ft. 6 ins.	
Depth at front, 6 " 3⅞ ins.; at back 5 " 7⅜ "	
Thickness: Side, crown and back plates	⅜-in.
Thickness, tube-plates	5-16-in.
Crown stays	Sling and radial
Fire-brick arch	On 2½-in. arch tubes
Stay bolts (drilled) diameter ⅞-in.; pitch 4 ins.	
Water spaces, front, 4½ ins.; back, 4 ins.; sides, 5 "	
TUBES: Iron; number	273
Thickness	No. 11 W. G.
Diameter, outside	2¼ ins.
Length over tube plates	18 ft. 1 in.
HEATING SURFACE AND GRATE AREA:	
Heating surface, tubes (exterior area)	2,893 sq. ft.
" " firebox	190 "
" " total	3,083 "
Grate area	49.5 "

THE TECHNICAL GRADUATE AND THE MACHINERY DEPARTMENT OF RAILWAYS.*

By W. F. M. Goss,† M. Am. Soc. M. E.

The technical graduate of the better schools of engineering is not, as many people have supposed, a boy, but a man. He may approach 30 years in age, and is never less than 20. The average age of 63 members of the department of Mechanical Engineering of Purdue Univer-

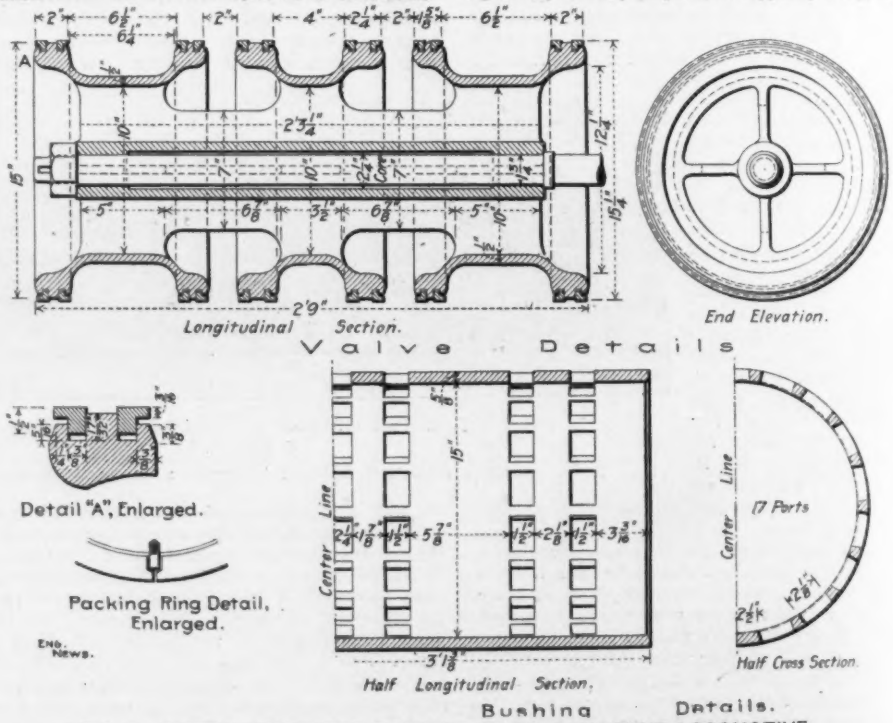

FIG. 3. PISTON VALVE FOR FOUR-CYLINDER COMPOUND LOCOMOTIVE.

*Abstract of a paper read at the March meeting of the Western Railway Club, Chicago.

†Dean of the School of Engineering, Purdue University, Lafayette, Ind.

sity is 22. The average graduate has good health, a good frame, and some muscle. As a day laborer he should be able to earn his wage. He also has some experience as a mechanic. In school he has had courses in shop practice which, while too limited to give him great skill, have served to enlarge his understanding of such matters. Many instances have come under my observation of men having no other experience than that afforded by the college shop, taking regular employment as machinists or pattern makers with satisfaction to their employers. Moreover, he has had a limited amount of actual shop experience

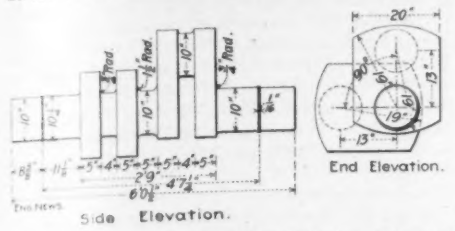

Fig. 4. Crank Shaft for Four-Cylinder Balanced Compound Locomotive.

either before entering college or during his summer vacation, or both. Of the class already referred to, there are but two men in a class of 63 who have not engaged in some regular work at a stated rate of pay. The longest period of service is approximately 9½ years; the average for the class is 2 1-6 years. Most, though not all of this service, has been rendered in shops or drafting-rooms. His school training, also, permits him at once to do useful work in any drafting room. All these are very commonplace qualifications, but they are too important to be overlooked by anyone who seeks to formulate an estimate of the graduate's ability to serve.

The average technical graduate has some unusual qualities of character. As a youth he persisted in his school work when many of his fellows having equal opportunity have dropped out to become wage-earners. At the close of the grammar school the ranks about him were thinned and again at the conclusion of the high school, many companions dropped away. But he kept in check his natural restlessness and entered resolutely upon the four long years of a college course. Nor has his part been entirely one of passive resistance. All along the way he has been subjected to severe tests designed to prove his worthiness to proceed. In the high school, at the entrance gate of the college, and throughout his college course, men have failed and departed, while he has passed on. Many of those who have proven themselves stupid, or lazy, or indifferent, or bad in habits, have been shaken out with the result that, whatever may be his faults or deficiencies on the day of his graduation, the fact remains that the technical graduate is a winnowed product.

Finally, the technical graduate in his knowledge of science and technology has a broad foundation upon which to build a life's work as an engineer. He is something of a scholar and is sufficiently trained in intellectual processes to be able to deal with facts as he finds them. The technical graduate is usually exceptionally pure in his impulses and purposes. He knows how to sacrifice and is

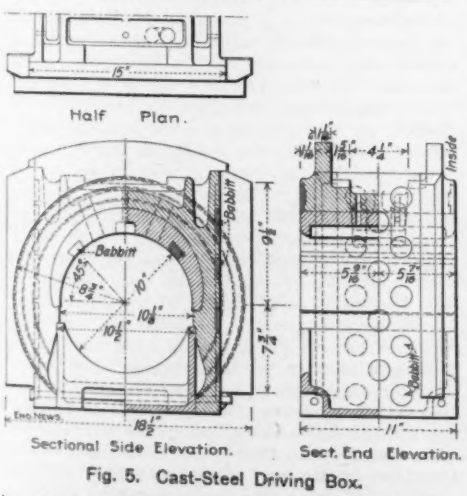

Fig. 5. Cast-Steel Driving Box.

honest and truthful. In many cases he has earned much of the money which he has spent as a student, and as a rule, he is always ready to work.

There are in this country approximately 60 institutions of recognized collegiate standing, having students in those departments of engineering which most closely touch the interests of the railway, namely: In civil, mechanical, electrical and chemical engineering.* In the year 1901-2, 48 of these institutions, embracing certain of the so-called land-grant colleges for which statistics are available, had in attendance upon the courses named a total of 9,084 students.* Full returns for that year would doubtless show a total for all institutions of between 10,000 and 12,000. Of this number, not less than 2,000 were graduated. Since 1902 the enrolment of students in most schools of engineering has materially increased, and the probability is that the number of graduates from the courses named will this year approach 2,500.

The absorption each year by the various industries of the country of 2,500 or more trained young men is a matter of no small significance. It requires no argument to show that these men include in their number many who will later have a prominent part in advancing the engineering practice of our country, and, hence, their distribution is a matter of some importance. If, for example, it were shown that some one industry receives and retains in its service a much larger share of these technical graduates than another having similar needs, it would be expected that its operations would in the long run become the more efficient, and, similarly, it would appear that an industry receiving less than its share must in the end suffer through lack of technical ability. In view of these facts it is of interest to inquire whether the motive power and car departments of railroads are getting and retaining their share of the technical graduates.

THE MOTIVE POWER DEPARTMENT AND THE TECHNICAL GRADUATE.—It is the experience of the college authorities that the number of graduates desiring to enter the motive power and car departments is small when compared with the number which the railway officials ask to have recommended to them. To those who have been interested in specializing the preparation of the college man for the work of such departments, this has been the source of some disappointment. Such a condition is in part due to the pressure of good times, and to the number and variety of chances which in recent years have presented themselves to the graduate, but it is none the less true that in competition the offer of the railway has not proved attractive.

Another condition which suggests that the motive power departments do not get their share of the technical graduates is to be found in the fact that this department takes a smaller proportion of graduates in mechanical engineering than the maintenance of way departments take of the graduates in civil engineering. Basing a comparison on the last two classes which have graduated from Purdue, but 21% of the mechanical engineers have entered motive power departments, while 55% of the civil engineers have entered maintenance of way departments. I fancy that the principal reason is that the inducements offered by the motive power departments are less attractive than those which are offered by the maintenance of way department.

Again, an examination of the pay rolls of railroad companies will show that the number of technical graduates of the apprentice grade in the motive power and car departments is not only relatively small, but actually so. On most western roads the number is less than one to each 1,000 men employed, while many roads of considerable size have no technical men in training. These considerations constitute strong testimony favorable to the contention that railways are not getting their share of the technical graduates for their motive power departments. There is a tendency in present practice to slight the technical and to emphasize the administrative side of the motive power department. It is only on the larger systems that any considerable amount of expert work is asked or expected of the department. Such work when necessary in the design of equipment or in framing specifications governing its construction, is in many cases offered by the supply houses and accepted by the railway companies. When unusual improvements are to be made, outside expert help is called in. Upon many roads the motive power and car department makes no real pretense at being a technical department. In so far as this condition applies, the fact must be recognized that the motive power department under these conditions presents no large field for the technical graduate. His place is rather with the railway supply houses which are in effect the engineering bureaus of such railways.

While it is undoubtedly true that the process which is responsible for the present practice has reduced costs, promoted standardization of equipment, and has proved in many ways highly beneficial to railroad companies, it may well be asked whether the provisions which serve for the work of to-day are likely to be sufficient for the practice of to-morrow. The conditions existing in the shop a generation ago were more favorable to the development of men than those which exist in the modern shop, while the demands which are to be made upon the official of the future are likely to be made more exacting than those which are made upon the official of to-day. All this leads to the conclusion that no motive power department should fail to have its group of technical graduates in training for its future work.

One other condition which is sometimes urged as a reason for not employing technical graduates is a difficulty

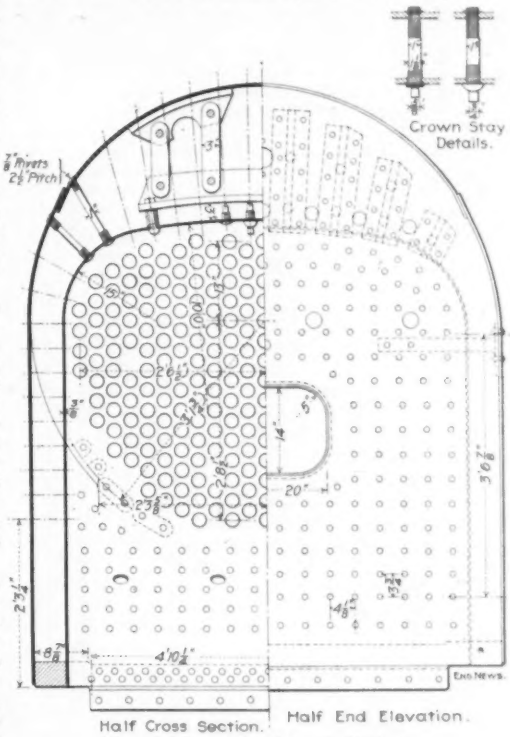

Fig. 6. Cross-Section of Firebox.

in finding work for them after they have finished their special apprenticeship. But is the difficulty real? If the technical graduate is a good man, there should be profitable work ahead. If he is not a good man, he should not have been tolerated through his special apprenticeship. Here stands the superintendent of motive power at the head of a corps of several thousand men. He is responsible not only for its present efficiency, but for its development for future service as well. Down beside him is the college graduate who has served his time; one graduate and 1,000 or 1,500 men who are not graduates. I am sure that no superintendent of motive power will wait for a vacancy before using the full strength of this young man. In looking over his organization, however well he may have done his work, he will see weak spots which

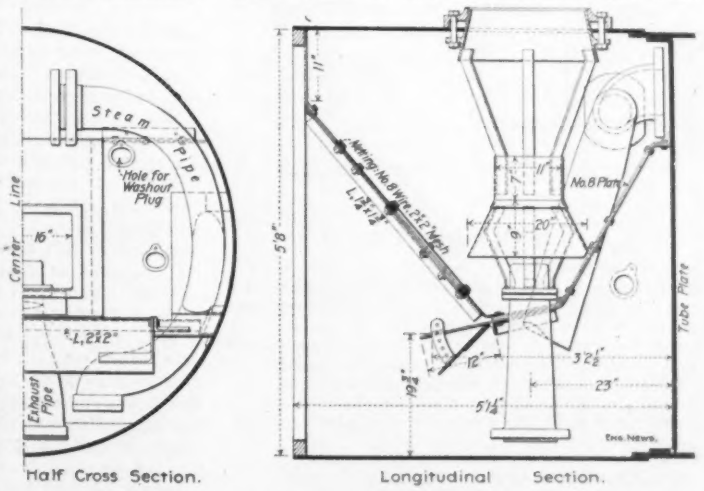

FIG. 7. FRONT END OF FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE.

ought not to be there; faults which may arise from the failure of a man, from the yielding of defective or of insufficient material, from a lack of a definite understanding of related facts. Having found the thinnest and least defensible spot in his whole organization, he will put his young man into it, perhaps merely as a multiplication table to a foreman whose practical training makes him valuable, but whose figures are bad, perhaps as an inspector of material, or as a student of failures in materials; but whatever the task, he will feel sure that if he chooses well, the young man will earn his salary, and will

*For complete list of institutions having courses in engineering, see Proceedings of the Society for the Promotion of Engineering Education, Vol. X, 1902.

*Report of the Commissioner of Education, Vol. 2, 1902.

at the same time be in training for the larger responsibility when it comes.

THE SPECIAL APPRENTICE.—To the technical graduate the motive power and car department of a railway offers two alternatives. He may enter the drafting room either in the capacity of a draftsman or with the expectation of soon becoming one, or he may enter the service as a special apprentice. If the former, his course is the result of purely business propositions. He is a workman, is recognized as such, and his opportunities for bettering his condition are subject to many of the limitations which apply to workmen.

The technical graduate who enters upon a special apprenticeship, by so doing announces that he intends to work for an official position on the road; and the company in accepting him, agrees to so train him that he may be worthy of such a position. In view of this compact, the special apprentice accepts a low wage, and the railway company undertakes to vary his task notwithstanding the fact that such a course limits for a time the usefulness of the apprentice. On a very few large railway systems the course for special apprenticeships has been

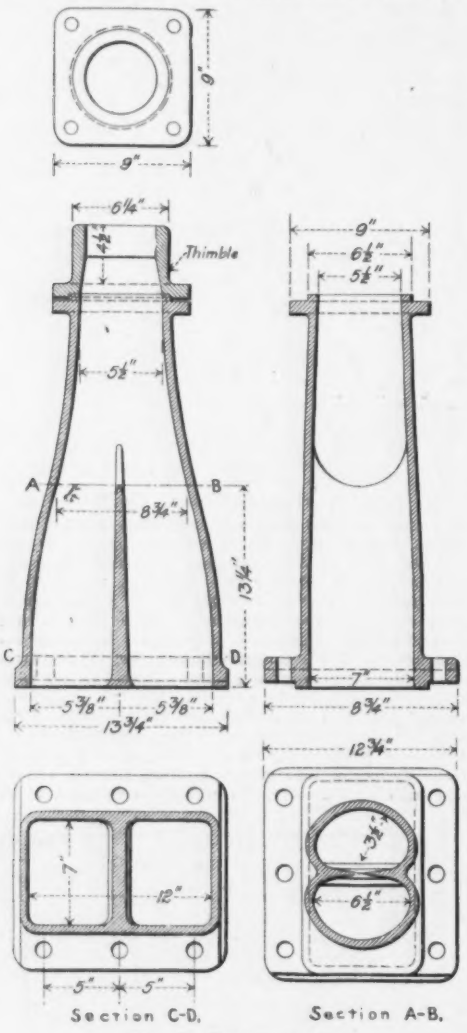

Fig. 8. Exhaust Pipe.

worked out with care. Students in such courses are handled with intelligence and consideration, with the result that they are satisfied, while the road accomplishes its full purpose in training men for its service. Most roads, however, undertake to receive special apprentices with no adequate understanding of their responsibility in the matter. It often happens that injustice is done the special apprentice and that in the end the road fails in its efforts to make him a means of strengthening its organization.

One defect is the low wage paid the special apprentice. He has depended upon others throughout his school and college course and has long looked forward to the time when he can begin to take care of himself. He is willing to deny himself many things; he will be content with rough clothes and scant fare, but except in rare cases, he must have self-support. This is not given him, as a special apprentice, and the opportunities of such an apprenticeship are, therefore, sealed against most graduates. Some roads have fallen into the habit of receiving technical graduates, ranking them as special apprentices, and of then undertaking to see how valuable they can be made to the road, without much regard for the rights of the graduate. By this arrangement it is possible to secure a man for 12 or 14 cts. an hour, who can run a lathe, make a drawing, summarize statistics, conduct an experimental investigation, inspect material, report on defective equipment, test a locomotive, figure the bracing for a boiler, outline a scheme for motor-driving in an existing shop, install motors, or interview a division superintendent in behalf of his chief. When a road keeps such a man busy under the hardest sort of conditions, perhaps transferring him to a roundhouse or division shop remote from the center of the road's activity, when he has no contact with men who can aid him and few opportunities to observe processes which can instruct, the attitude of the road toward him is lacking in that element of fairness which is essntial to permanent success.

Another defect in the present special apprentice course is the long continuance of a deadly parallel. By the present practice all men are treated, or at least paid, alike, usually throughout a three years' course. It takes unusual qualities of character to inspire a man to unusual and long-continued effort when his companion who makes no such effort receives the same recognition as himself. The difficulties which in a railway organization arise with this objection are great. Nevertheless, for best success the system must individualize the man before he reaches the age of 25. This the special apprenticeship fails to do. Either the rate of pay should be varied during the last two years, or the formal course should be shortened.

Again, underlying the special apprenticeship course as administered upon most railways, is a conception that the technical graduate must be made to overcome as many difficulties as possible. He is set to work with a gang of men unfriendly to his purpose and to him, he is often required to work under a foreman whose chief desire for the time being is to make him show a white feather. He is given the heaviest end of the lever and is required to keep lifting long after the necessity for effort has passed. As a rule, he does not complain, but even though the process seems to work out successfully, it may not be wise. It tends to dwarf the man rather than to draw him out. Manufacturers in dealing with the same matter have learned to handle it in a much more satisfactory way, their plan being to give the technical graduates official recognition from the beginning. My plea is not that their task be light, but that they be given such reasonable opportunity as will make their position attractive to the average man. In urging this plea, I assume that I am serving the railroad companies quite as much as the technical graduate.

Finally, as opposed to much of the criticism which I have urged, it is sometimes said that even though the work of the special apprentice is unremunerative and difficult, his reward is sure and in the end sufficient. But is this true? Popular sentiment or fancy lends a halo of brightness to the official position of a railway, but the time has long since passed when sentiment could be made an important factor in a business contract. Is it true that the degree of official recognition which awaits the average technical graduate in the railway service is greater than that which awaits him in the service of corporations of other sorts? If it is not true, is it good policy on the part of the railway corporation to make its early work less attractive than that of other corporations?

A PROTECTED SECTIONAL THIRD-RAIL SYSTEM OF ELECTRIC TRACTION.

While the third-rail system of electric traction possesses many advantages over the trolley system, it possesses certain disadvantages and dangers in its present form. Prominent among these is the exposed condition of the conductor rail, involving constant risk of danger to persons on the track, and also a loss of generated power. Two methods of eliminating this risk are: (1) The protection of the third rail so that it will be practically impossible for people to come in actual contact with it; and (2) the division of this rail into sections, and so distributing the current that in each section the rail will be energized only while a car is passing along that section. In our issue of Jan. 14 appeared a letter from Mr. E. W. Farnham, referring to his protected sectional system, in which both of the above methods are combined, and we are indebted to Mr. Farnham for further particulars of the details of this system, which is now being introduced by the Farnham Co., 108 La Salle St., Chicago.

Taking up first the protection of the third rail, this is clearly shown in Fig. 1. The rail is an inverted T-rail, rigidly suspended in insulated chairs or brackets, placed on every fourth tie. The rail, A, is gripped by a special insulating clamp, B, about 8 ins. long, which embraces the web and flange. This is wedged in by blocks of maple, C C, soaked in paraffine, driven between the insulator and the jaws of the casting, D. Studs, E, passing through these jaws enter the wooden blocks, and so support the rail without the use of bolts or nuts. The rail and its support are enclosed in a protecting casing of U-section, F, while the feeder cables are laid in the upper chamber of this casing, at G. A light insulated cover, H, closes the top of the casing and thus protects the feeder rail and wires from snow and rain. The contact shoe, J, is of the under-running type, and is attached to the journal boxes of the truck (taking its radial position from the king-bolt center) instead of being attached to the truck frame, as is the usual practice. Each shoe is carried at the end of a hollow bar or tube, K, through which the wires pass, and which is pivoted to the bracket, L, anchored to the journal boxes or equalizer bars. The shoe is held up against the rail by the spring, M, giving a contact pressure of about 3 lbs. With this construction, the third rail is thoroughly protected against snow and sleet, and persons cannot accidentally come in contact with it or with the wires carrying power to the car.

A special feature of this part of the system is the insulating clamp, B, which is made of a material invented by Mr. Farnham, and has an exceptionally high insulating power. In tests made by Prof. Woodworth, of Lewis Institute, Chicago, in January, the section was firmly secured by clamping the supports between the jaws of an iron vise. The supports and the rail formed the two terminals of a 30,000-volt 5-KW. transformer supplied with sine-wave alternating currents. The voltage was raised until the insulation, ¼-in. thick, broke at 25,600 volts. In one test there was a small spark discharge at 21,000 volts and a complete jump at 25,600 volts. In another test, a slight spark occurred at 21,000 volts, and a complete jump at 25,000 volts. As power circuits do not exceed 600 volts, direct current, there is a very high factor of safety.

We may now take up the sectionalizing of the system, by which current is normally shut off from the third rail, and is only turned on for any section when a car is in that section. Safety stop and block signal wires are carried across the insulated joint between the sections to any desired distance beyond the joint; that is to say, the signal of section No. 1 is operated by the power on the third rail in section No. 1 against section No. 2, while the signal of section No. 2 is operated from the third rail of section No. 2 against sections Nos. 1 and 3, and so on.

Take the case of a car in section No. 2, as shown in the diagram, Fig. 2. Having entered the section it sets a block signal and an automatic stop behind it in and near the end of section No. 1, this being effected by a connection with the third rail; it also sets a similar protection in section No. 3 ahead of car. The third-rail sections are normally insulated from each other. Near the end of each section is placed an additional contact surface, electrically connected with the power control apparatus described below. This contact consists of a piece of third rail on the opposite side of the track from the main third-rail conductor. As this contact is reached by the car in section No. 1, the joint is bridged and the power being used by the car is utilized to operate the control in the next section ahead, No. 2, energizing the conductor rail of that section ready for use by the car upon entering the section. After the car has passed entirely into the succeeding section, No. 2, leaving the last occupied section, No. 1, without any outlet for the current, another contact is made, utilizing the operating power of section No. 2; this de-energizes the last preceding section, No. 1, leaving it "dead."

As the car nears the end of section No. 1 to pass into No. 2, if the section ahead (No. 2) is clear, signals and safety-stops will also be clear and the car may proceed. This operation is repeated section after section until the car encounters a "stop" signal and safety-stop, indicating that the next section ahead is already occupied. Unless the car under consideration stops before reaching the signal set against it by the car in the next section ahead, an automatic stop would shut off the current and apply the air brakes. All of these movements are operated electrically through the power control apparatus, which is claimed to be the only operative device known which makes the sectional system possible. Suppose the car is thus stopped in section No. 2 by a car in section No. 3. Then

after the car ahead has passed into section 4, the other car may again get current, and pass into section No. 3. The shutting off of power and applying the brakes on the car passing a "stop" signal does not shut off the current from the conductor rail of the rear section, so that the offending car is still protected from a third following car by the signal and safety-stop at the rear end of section 1.

In the event of a derailment on the ordinary third-rail track, the contact of the wheels or a metal truck frame with the third rail may short circuit this rail with the running rail. This has led to several accidents, in which cars have been burned and passengers injured. In the Farnham system, however, the power control apparatus immediately shuts off the power when a short circuit is formed.

At road crossings, the third rail being protected and normally "dead," is carried up close to the planking of the crossing, normally 16 ft. wide, and electrical connection is made with the rail on the other side by means of an underground cable. On short crossings the shoes on the front truck of a car would make contact with the third rail on the far side before that of the rear truck had left the rail on the other side. On long crossings the car would drift over. To protect busy crossings, a signal may be installed, which will indicate danger while a car is within a distance of ¼-mile or more, if desired.

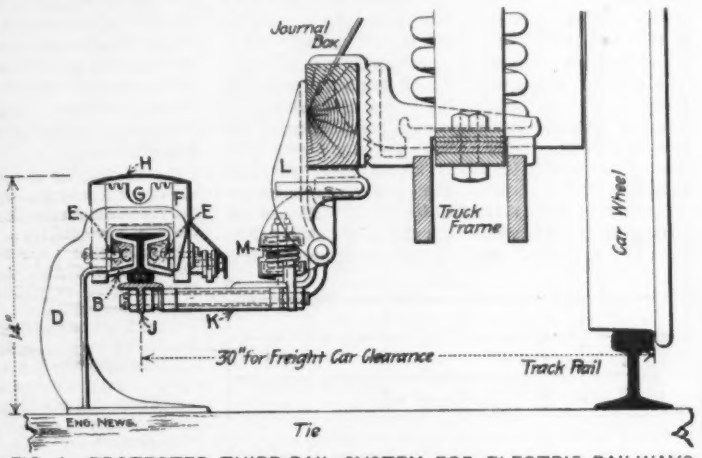

FIG. 1. PROTECTED THIRD-RAIL SYSTEM FOR ELECTRIC RAILWAYS.
E. W. Farnham, Chicago, Inventor.

The power-control system referred to above is an electric mechanical circuit closer, the invention of Mr. Farnham. It is operated by the moving car, switching current from the main feed wires to the protected third-rail car feeder in advance of its requirement, and likewise cutting the current off after the given car has passed beyond a given section and the outlet for the current through the motors has therefore been cut off, thus obviating all possibility of arcing and sparking. In its general application, the power control is operated either by an oscillating or plunger movement, as may be desired. The control as now made is of the former type, all of the contacting parts being carried upon a vertical shaft about 18 ins. long, resting upon a ball cup bearing. Mounted upon this shaft at its lower end is a copper segmental closing bar or blade about 1½ ins. thick and 5 ins. high. At either side of the shaft, and insulated therefrom (as well as from each other), are two banks of copper fingers, each about 5 ins. high, and placed about 4 ins. apart, so that when the current is required, the segmental blade makes a quarter turn between the fingers, thus completing the circuit, one set of fingers being connected with the main feed wires and the other with the protected third rail. When current is not upon the third rail, the segmental blade stands parallel to the two banks of fingers, with an air space of about 1½ ins. on each side.

The oscillating of this shaft and closing blade is accomplished by the use of two crescent or semicircular solenoids with a circular armature or core for each solenoid, one to put the power on and the other to cut it off. The operation is as follows: When the car contacts a certain point just before entering a new section, a current is shunted through one of the solenoids, which draws in the armature and causes the segmental bar to make a quarter turn. This energizes the section, and at the same time opens within the machine the circuit over which this operating power was transmitted to the electrical portion of the control and closes a similar circuit to the releasing solenoid, ready for cutting off the power when the car has passed to the next section. From this it will be seen that when once set, it is immaterial how many collectors or shoes may contact the operating point; no damage can result therefrom, as the circuit is open. When the car passes into the next section after having set the former control, a like "release" contact will return the last section control to a position of rest, opening the release circuit, and likewise close the current ready for the next car coming into the section to close the power control to the third rail.

In protecting a train and passengers against accident in case of a direct short-circuit, the release circuit is short-circuited within the control, throws the power off and holds it off until the short-circuit has been removed, thus preventing any other train or car from obtaining power in that section. Should this latter condition obtain, the trespassing car will have no power to throw off the power control in the last occupied section, and the motorman must encounter his own safety stops should he coast far enough into the "dead" section, and be thereby stopped by having his power cut off and air brakes set. At all times when a car is in the danger zone, it is protected against accidents from head end or rear end collisions. The same control is exercised in case of open or misplaced switches, set either accidentally or maliciously.

In 1902 the company leased a side track a mile long on the Chicago, Burlington & Quincy Ry., near Chicago, and equipped it with the system above described, using a heavy interurban car. This was in experimental operation for over a year. The company now has a contract for building and equipping the Dayton & Kenton electric line from Dayton, O., to Kenton, O., a distance of 104 miles. Work will be commenced in the spring, and the Farnham system will be used throughout. The company has also under consideration contracts for other roads.

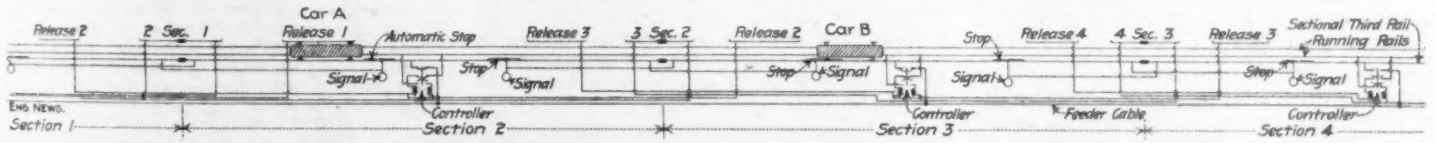

FIG. 2. DIAGRAM OF FARNHAM SECTIONAL THIRD-RAIL SYSTEM.

A COMPARATIVE STEAM-PUMP TEST WITH SATURATED AND WITH SUPERHEATED STEAM.

By John Primrose.*

In the early part of this year, one of the boilers at the Spring Creek pumping station of the Brooklyn Water Works was equipped with a Foster superheater in order to determine, by comparative tests, the amount of saving due to superheating the steam.

*Chief Engineer, Power Specialty Co., 126 Liberty St., New York, N. Y.

The Spring Creek pumping station is one of a number of small stations which secure their supply from driven wells and deliver into a conduit which carries the water to the Ridgewood pumping station. From there it is delivered to the reservoir by more economical engines of larger size and power.

The equipment of the Spring Creek pumping station consists of two horizontal return tubular boilers, each 60 ins. in diameter by 15 ft. long, having 66 3-in. tubes and 914 sq. ft. of heating surface. Each boiler has 25 sq. ft. of grate and natural draft. The fuel burned was large size white-ash anthracite. The pumping plant consists of two Knowles compound condensing direct-acting duplex pumps, size 6½ and 11½ × 16 × 24 ins., and one Davidson triple-expansion condensing direct-acting simplex pump, size 8, 14 and 24 × 24 × 24 ins. These three pumps are equipped with independent jet condensers, the exhaust steam from which is used to heat the feed water to the boilers.

The pumps get their water through a common suction pipe from the driven wells and deliver it through separate delivery pipes into the conduit, the total head against which they work being in the neighborhood of 30 ft. On its way to the conduit the water flows over a weir, making it easy to check the plunger displacement. The Foster superheater fitted to one of the boilers consisted of a double row of ribbed cast-iron elements set vertically in the fire-chamber at the rear of the boiler. The two rows of elements are connected at the bottom. Steam from the boiler enters the front row at the top, and leaves the superheater at the top of the rear row. The superheater was connected to discharge into the old steam main, making it possible to run a test on each boiler under the same conditions.

It was decided to run two tests—one using the boiler containing the superheater and a second using the boiler without the superheater. In both tests the main object was to determine the amount of work which could be developed per 100 lbs. of coal. It was decided to base the results on the weir measurement and careful measurements were taken and checked by plunger displacements. In the first test the "slip" was 22.3%, in the second 22.2%, checking very closely. That these figures are so high is explained by the fact that the water as it comes from the wells contains a very large quantity of air, and further by the fact that the pumps did not make full stroke. The coal and feed-water supplied to the boiler during both tests were carefully weighed. The station was in charge of the regular crew and no attempt was made to direct their handling of the plant during either test.

The first test was made using the boiler containing the superheater and lasted 24 hours, starting at noon February 8th and ending noon February 9th. The boiler without the superheater was then cut in and the other shut down. After running a few days to get properly warmed up, a 24-hour test was started, using the boiler without the superheater, starting at 11 A. M. February 11th and ending 11 A. M. February 12th.

The results obtained on the two tests were figured back to the same basis for comparison; that is, the footpounds of work done by the pumps (as measured by the weir and the total head pumped against) per 100 lbs. of coal and per 1,000 lbs. of steam, termed duty of the pump. It was shown by this comparison that 25½% more work was developed from 100 lbs. of coal and 30.2% more work was developed from 1,000 lbs. of steam when superheated about 200° F. than was developed when the steam was saturated. Also that the same amount of work was accomplished with a saving in coal of 20.2% and a saving in feed water of 23.2%.

Since making the above test a five days' run with superheated and an equally long run without the superheater were made; the station records show that during the five days without the the superheater the station pumped 22,337,500 of water with 31.780 lbs. of coal, and that with the superheater the station pumped 22,337,(500 gals. of water and burned 23,730 lbs. of coal, showing a saving of about 25%. Following are the figures obtained during the two 24-hour runs.

Tests of Spring Creek Pumping Plant, Brooklyn, N. Y., Showing Economy of Superheated Steam.

	Superheater—With.	Without.
Date	Feb. 8 and 9.	Feb. 11 & 12.
Time, start	12 M.—8th	11 a.m.—11th
Time, finish	12 M.—9th	11 a.m.—12th
Length of run	24 hrs.	24 hrs.
Avg steam press., lbs. per sq.in.	79.3(?)	79.4
" water " del'y, triple*.	.90	1.05
" water " compound* ..	7.10	7.10
" vacuum of suction, triple and compound.†	22.90	23.21
Total head, triple, ft. of water	29.05	29.46
" head, compound.*	33.04	33.39
" counts triple	30,557	34,114
" counts compound	35,395	32,158
Gallons pumped, triple.§.....	2,854,023	3,186,247
Gallons pumped, compound.§..	2,930,706	2,662,682
Total gallons pumped:		
From plunger displacement..	5,784,729.8	5,848,930
By weir measurement	4,492,680	4,549,480
Slip of pump.....	22.3%	22.2%
Foot-lbs. work—both pumps:		
From plunger displacement..1,497,832,458		1,523,115,162
From weir measurement 1,163,815,819		1,184,983,596
Total coal consumed.....	5,015 lbs.	6,410 lbs.
Refuse.....	23.7%	18.7%
Total refuse	1,188 lbs.	1,203 lbs.
Total feed water	38,399 "	50,900 "
Duty per 100 lbs. coal.....	23,206,696	18,486,483
Duty per 1,000 lbs. steam.....	30,308,498	23,253,213
Average temperature steam:		
Leaving superheater	527.4° F.	
Entering superheater	320.1° F.	
Average superheat	207.3° F.	
Economy of superheating:		
Inc. of work per 100 lbs. coal	25.5%	
Inc. of work pr 1,000 lbs. stm.	30.2%	
Saving, coal per ft.-lb. work	20.2%	
Feed-water per ft.-lb. work	23.2%	

*In feet of water.
†In inches of mercury.
§From plunger displacement.

These tests are particularly interesting as showing the value of superheated steam in a plant which is of ordinary low duty type and has been in operation for several years on regular city service. No special arrangements were made for the introduction of superheater steam and no special oil or stuffing box packing nor steam pipe gaskets were used. The plant is in the same condition as it has been running for years past. The percentages of saving by superheating may appear to be high, but experience has shown that a greater gain in economy is to be obtained in a low duty than in a high duty plant. Mr. F. W. Dean remarked in a recent address before the New England Water Works Association that one of the most promising fields for increasing the duty of steam pumping engines, and in fact about the only remaining correction or radical improvement was using superheated steam in place of saturated steam. The results obtained in Brooklyn would seem to bear out this opinion with greater positiveness.

DESCRIPTIONS OF THE REGULAR MARKS UPON CORNER AND QUARTER-CORNER STONES OF THE U. S. PUBLIC LAND SURVEYS.

By W. Newbrough.*

In all the works upon surveying with which the writer is acquainted no mention is made of the system used to mark government stones, and no directions are given to enable a person to identify a corner by its marks.

The marks on section corners are horizontal notches and mean miles. Corners are marked upon the sides (or edges) from which surveyed lines extend. If no survey line has been run from one or more sides of a corner, no notches are placed upon that side or sides, showing that the government survey does not extend in that or those directions. This remark does not apply to section corners on township and range lines. In a fully surveyed country, township corners, or more properly corners common to four townships, are marked with six notches on all four sides, meaning that the distance to other corners common to four townships is six miles. If, however, these corners are standard or closing corners, they are marked with six notches on three sides and the letters C. C. or S. C. (for closing or standard corner) on the side from which no government line extends.

Corners on township lines are marked on the east and west sides with the number of notches showing the number of miles east and west to the township corner. Thus the northwest corner of section 1 is marked 1 notch on E. and 5 notches on W. sides. If these corners are upon a standard line the letters S. C. or C. C. are also placed upon them.

The accompanying diagram gives the marks on section corners when everything is regular.

The interior corners of a township are marked on the south and east sides, the number of notches designating the number of miles the corner is situated from the south and east boundaries of the township, respectively. Thus the southwest corners of sections 1, 12, 13, 24, 25, 36 are all marked with one notch on the east; and the southwest corners of sections 13, 14, 15, 16, 17, 18 are all marked with four notches on the south side. (See Fig. 1.) A corner marked four notches on the

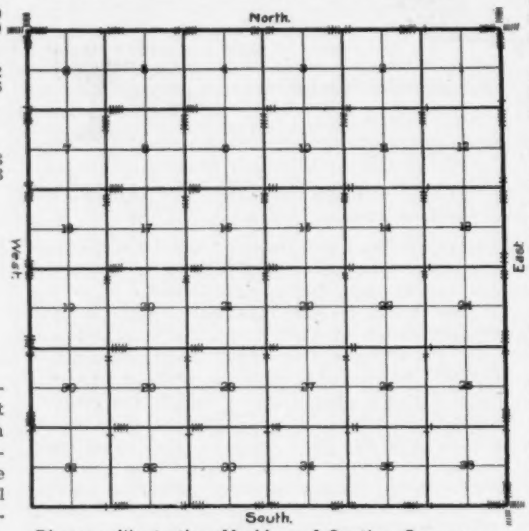

Diagram Illustrating Marking of Section Corners on U. S. Land Surveys.

south and three on the east, would be four miles north and three miles west of the south and east township boundaries. Counting these off on the diagram, Fig. 1, it is found to be the corner common to sections 9, 10, 15, 16.

Section corners on range lines are marked on the north and south sides, similarly to those on township lines.

Quarter-section corners on north and south lines are marked ¼ on the west side; on east and west lines ¼ on the north side.

The foregoing are the regular markings and the ones which usually occur. Markings for special corners as meander, auxiliary meander, reservation and other corners can be found in the Manual of Surveying Instructions of the General Land Office, and in some works on surveying. It may be well to mention, however, that "Witness Corners" have the letters W. C. upon them in addition to the marks.

COST OF RAILWAY BALLAST.

In discussion of the report of the Committee on Ballast, of the American Railway Engineering and Maintenance of Way Association, the following information has been issued by the Association. The table below was furnished through the courtesy of Mr. W. C. Cushing, Chief Engineer, Maintenance of Way, Southwest System, Pennsylvania Lines:

Record of Experimental Test of Three Different Sizes of Broken Stone Ballast on the Baltimore & Ohio Ry., from August, 1899, to October, 1903 (both inclusive).

	Size of Stone Ballast. 3-4 in.	1 1-2 in.	2 1-2 in.
Double track ballasted (ft.)	5280	5211	5280
" " " (miles)	1.0	0.987	1.0
Stone ballast used (cars)	228	171	198
" " " (tons)	6200 ½	4651 16-2¾	4948
Cars of stone per mile of double track	228	173	198
Tons " " " " "	6200	4713	4948
Lin. ft. of double track covered by 1 car of stone	23.1	30.5	26.7
Lin. ft of double track covered by 1 ton of stone	0.85	1.12	1.07
Average depth of ballast under ties	7 1-4 in.	6 1-2 in.	6 3-4 in.
Total first cost of ballast, freight, unloading, putting in tracks, lining, surfacing, etc.	$7911.60	$5633.51	$5263.92
Average cost per ft. of double track	$1.50	$1.08	0.997
" " " mile of double track	$7911.60	$5708.10	$5263.92
Cost of ballast per ton at quarry	$0.60 to 0.70	$0.60 to 0.68	$0.58 to 0.69
Average cost of maintenance for period of 51 months	$94.66	$84.94	$82.13

TYPHOID EPIDEMIC FROM A CONTAMINATED WATER SUPPLY AT WATERLOO, IA.

A typhoid epidemic at Waterloo, Ia., during the past winter is now believed to have been due to the water supply. Recent examinations by Professors Walter L. Bierring and Henry Albert, of Iowa State University, showed that streams from which the water is taken to be contaminated with sewage. The water is filtered through mechanical filters before delivery into the mains. The following is quoted from the official report of the experts:

The analysis of the river water, before the intake of the city water supply, during the several stages of filtering process and after filtering, taken at different places in the city, gave results as follows:

1. Cedar river water just above intake—Number of bacteria per c. c. 25,210. Both typhoid and colon bacilli were found present, as well as other bacteria indicating sewage contamination.

2. Both typhoid and colon bacilli were found present in the different stages of the filtering process; the water in the filter after the latter had been washed and was again ready to begin filtering contained 53,100 bacteria per c. c.

3. Water filtered—Coming from filtered tank one minute after washing of filter contained 42,160 bacteria per c. c. Both typhoid and colon bacilli were found present.

4. Water filtered five minutes after washing of filter—Number of bacteria per c. c., 11,970. Both typhoid and colon bacilli were found present.

5. Water filtered forty minutes after filter had been washed—Number of bacteria per c. c., 8,640. Both typhoid and colon bacilli were found present.

6. Water obtained from tap at Irving House—Number of bacteria per c. c., 7,230. Colon bacilli were found present, but typhoid bacilli were not to be detected.

Cedar river water one-half mile above Cedar Falls sewer—Bacteria very numerous (21,800 per c. c.). Many colon bacilli, but no typhoid bacilli found.

Cedar river water ten feet below opening of Cedar Falls sewer—Bacteria exceedingly numerous (188,000 per c. c.). Colon bacilli numerous, but no typhoid bacilli found.

Cedar river water one hundred feet below opening of Cedar Falls sewer—Number of bacteria per c. c. 126,000. No typhoid bacilli found, but colon bacilli were very abundant.

Blackhawk creek water, one mile above river—Bacteria very numerous, 187,000 per c. c. Colon bacilli present, but no typhoid bacilli found.

Virden creek water—Number of bacteria per c. c. 29,400. No typhoid bacilli found. Colon bacilli numerous.

Cedar river water below Waterloo sewer outlet—Number of bacteria per c. c., 166,800. Typhoid and colon bacilli both found present. The typhoid bacilli being specially prominent.

The bacteriological examinations made indicate that the river is contaminated with sewage material and contains the germs of typhoid fever; that these organisms are especially abundant in the sediment which accumulates on the surface of the sand in the filter during the process of filtration; that the stirring of the sand in the filter and its washing with filtered water does not, by any means, remove all the organisms present; that the water first filtered after the washing of the filter contains even more micro-organisms than are found in the river water, but the number is rapidly diminished as filtration goes on. The finding of typhoid bacilli in the water soon after the washing of the filter, means of course that these germs have entered the supply mains of the city and have thus contaminated the water.

. . . . . .

You will note that the difficulty lies with the city water and is due to an inefficiency of the filtering process. We believe, however, that the filtering plant is well equipped to do good work, that it is operated by an excellent management and that the fault in the plant can be remedied.

*Evanston, Wyo.

To remedy the defect in the filtering system, we would suggest that the water passing out of the filter for the first half hour be permitted to escape through the sewer system. That the sand in the filters be frequently sterilized, if necessary, after each washing.

These questions come, however, more frequently within the sphere of the sanitary engineer, and we would recommend that an expert on that subject be secured to remedy all defects in the filtering plant.

THE WATER SUPPLY OF ALBION, N. Y., which was criticised in a letter by Mr. E. C. Mills, of Rochester, published in our issue of Feb. 25, has been condemned by the engineer of the State Board of Health, Prof. Olin H. Landreth. The point at issue was whether percolation of canal water into a system of wells was causing contamination. The following is an extract from Prof. Landreth's report:

The Albion Water-Works company's pumping station is located west of the village, and about 500 ft. from the Erie canal. The supply is drawn primarily from a system of ten driven wells and one large dug well, all situated within 300 ft. of the station.

Early in the use of the system, it became evident that the wells unaided were not furnishing the necessary amount of water, and the company, as a means of supplementing the natural supply from the wells, dug a system of narrow basins or trenches along each side of the lines of wells and a large basin near the wells. These basins are, during the season, supplied with water from the canal by two pipes extending from the canal; one an 8-in. pipe leading into the large basin, from which the water may percolate and may also overflow into the trenches; the other, a smaller pipe leading into a small waterway with which the trenches are connected and across which waterway, below the trenches, a small dam has been built by the company to hold back the water and throw it back into the trenches. The excavations for these basins extend in places through the impervious surface soil and into the sand and gravel from which the wells draw their supply, so that the water from the basins or trenches tends to percolate down into the ground water near the wells, and thus into the wells.

The trenches are so near the wells that when the trenches are full the water stands around and in contact with the tubes of some of the wells. The canal water is clearly unsafe for potable uses even after receiving the uncertain and probably slight improvement from the slight filtration it receives in its percolation through short lengths of gravel intervening between the bottom of the trenches and the bottoms of the well tubes. In my opinion its use is attended with great danger and should under no circumstances be permitted. It is recommended that the proper local authorities be instructed to notify the responsible officials of the water company that the furnishing of canal water in manner above stated as a part of the public water supply of the village of Albion is a menace to health and must be discontinued; and further, as a necessary protection against the passage of surface water, whether from the canal or elsewhere, into the wells without adequate and long-distance percolation, the trenches surrounding the wells and all the low depressions near the wells be filled up with clean gravel, sand or natural soil free from organic matter, and smoothly graded, so that the water may not collect nor stagnate near the wells.

WATER RESISTANCES for use in testing combined engine-generator sets at the builders' works are referred to in a paper on "The Equipment of an Engine Test-House," read before the (British) Institution of Electrical Engineers a short time ago by Mr. R. K. Morcom. The paper describes the testing equipment of the works of Belliss & Morcom, well known English builders of high-speed engines. For the electrical load the first form of resistances tried were wire resistances, but they gave much trouble. Various forms of water resistance were then developed. Iron tanks were found useless because they shunted the current through the tank-walls. For moderate voltage a fairly satisfactory resistance was made by inmersing double hollow cones in a tank through which canal water was kept flowing by means of a by-pass on the condenser circulating pump. This water had a very good conductivity. The cones are arranged vertically, large end up. The inner cone can be raised or lowered by a screw spindle, and the load thus varied. The outer cone must be kept below the water surface to allow circulation in the annular conducting space. These cones can be used in iron tanks, since the current flowing between the cones can not pass through the tank-walls. For high voltages long wooden tanks of small cross-section are used, with two iron plates immersed in the water serving as electrodes. The plates are hung on insulated rollers which can travel along the top of the tank to vary the distance between the plates. Care is necessary in controlling the water circulation in order to get steadiness of load. The current is led to the electrodes by flexible cables. For polyphase work subdivided tanks are used so as to give a separate resistance for each phase.

THE ANNUAL LOSS OF THE UNITED STATES by typhoid fever was estimated by Dr. Victor C. Vaughn at $90,000,000, in a recent address before the Michigan Municipal League. He assumed the annual number of cases of typhoid fever at 500,000 and the annual deaths at 50,000. Estimating the value of each life at $1,000 gave $50,000,000 as the annual loss by deaths. Assuming each patient who recovers to be ill for 40 days and to thus lose time worth $40, and to be subject to an average expense of $40 for doctors, medicine and nursing, an additional total of $40,000,000 is obtained. Thus says Dr. Vaughn: "The people of the United States are paying an annual tribute of $90,000,000 because of their ignorance, through the existence of a disease which, if every man did his duty, would not exist at all."

ELECTRIC POWER DISTRIBUTION TO WEAVERS has proved quite successful in several communities in France and Germany, according to "Oesterreichs Wollen und Leinen Industrie." In Lyons, where most of the silk weaving is done by home workers (35,000 looms against 30,000 factory looms), an electric distribution scheme was begun in 1895, and some 500 looms are now supplied. Power (and light) for a single loom costs 75 francs ($15) per year, for 250 hours per month (about 11½ hours per day). The spread of electric driving has been hindered by the fact that the hand looms cannot readily be altered to power, so that new looms must be acquired. The supply company has granted loans for this purpose free of interest. It is found that the earnings of the weavers are much increased by the use of power; with two hand looms the average income per year was 800 francs ($160), while with two power looms this rises to 1,500 francs ($300).

In St. Etienne, France, in ribbon work, electric driving has been introduced to even larger extent, as the looms used here were easily altered to power operation. The charge for current is 90 francs ($18) per year for each loom. The rental for the motor is 1 franc per month. In 1901 some 3,100 weavers with a total of 7,000 looms were supplied with current.

In the parish of Anrath, near Krefeld, Germany, a ribbon-weaving district, an electric supply company for furnishing power and light to weavers was formed three or four years ago. About 1,000 house workers are now supplied. Current is supplied from 7 to 12 a. m., and from 1:30 to 8 p. m. The cost of current is 60 marks ($15) per loom per year. The undertaking is already on a paying basis, though in operation only two years.

A similar system intended to supply some 28 communities is projected in the duchy of Baden, Germany, with the aid of a contribution from the state. The public advantages of supplying electric power and light to individual weavers are the greater output of the work which tends to preserve home weaving as an industry, and the greater convenience and healthfulnss of the work resulting from the elimination of muscular effort and the better illumination.

THE COMPULSORY ADOPTION OF THE METRIC system came before the British House of Lords recently. Its supporters, headed by Lord Kelvin, desired it to be considered at once, but against their objections it was referred to a special committee. The supporters of the bill argued in its favor that it would bring "enormous advantage to trade," while the difficulties of its introduction in factories, great or small, "would in a month's time be far more than compensated for by the diminution of labor which the change would produce."

THE INTRODUCTION OF THE METRIC SYSTEM in the British Empire was discussed two years ago at a conference of the Colonial Premiers, in London. Resolutions were adopted recommending the matter to the attention of the various provincial governments. Following this, the Colonial Secretary sent an inquiry to the governors of the various colonies asking for an expression of views on the subject of the metric system. Most of the governors have replied, and their answers are summarized in the London "Electrician" as follows:

The metric system is already used in Mauritius and Seychelles. The following are favorable to the adoption of the metric system:—Australia, New Zealand, Cape of Good Hope, Transvaal, Orange River Colony, Southern Rhodesia, Gambia, Northern Nigeria, Gibraltar, British Guiana, Trinidad, Leeward Islands and the Windward Islands. The following are favorable provided that it is adopted in the United Kingdom or in the Empire generally:—Sierra Leone, Southern Nigeria, Ceylon and the Falklands. Hong Kong would take common action with the other Colonies. The States of New South Wales, Victoria and Western Australia are favorable, but, together with South Australia and Tasmania, they consider that the matter is one for the Commonwealth Government. Fiji is doubtful, but says it must follow Australia and New Zealand, as also would British New Guinea. Jamaica and British Honduras require the adoption of the system in the United States; the Straits Settlements and Labuan would follow India in the matter, and the Bechuanaland Protectorate would be guided by the rest of South Africa. The following are on the whole unfavorable:—St. Helena, Cyprus, Lagos, Wei-hai-wei, Barbados and Bahamas. The Gold Coast Colony and the State of Queensland, whilst prepared to adopt the metric system, consider that inconvenience would occur thereby. Natal will not consider the matter until some general lines of legislation have been agreed upon by His Majesty's Government. No definite reply has been received from Newfoundland, Malta or Bermuda, and Canada has not yet replied.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Michigan Central Ry. near Niles, Mich., on March 25. A freight train was wrecked by a washout and two of the trainmen were killed.

A METALLURGICAL LABORATORY with assay department, in operation, will be the exhibit of the Colorado School of Mines at the St. Louis Exhibition. For this a space 25 × 50 ft. has been assigned in the Metal Pavilion, opposite the Mines and Metallurgy Building. The equipment will consist of a coal furnace and two gasoline furnaces, with the necessary accessories, four desks for chemical work, and a dust-proof balance room enclosed in glass. There will also be eight cases for general display. Regular assays will be made to show the methods of work, and specimens submitted by visitors will be assayed free of charge. The coal furnace and the equipment for assay and metallurgical work will be furnished by the Denver Fire Clay Co.; the gasoline furnaces by Wm. Hoskins of Chicago, and F. W. Braun, of Los Angeles, Cal.; the balances by Ainsworth & Son, of Denver, Colo., and the entrance archway and mosaic floor by the Colorado Portland Cement Co. The work of the laboratory will be done by students of the Colorado School of Mines, under the direction of a committee of the faculty consisting of Victor C. Alderson, President; F. W. Traphagen, Professor of Metallurgy and Assaying, and Herman Fleck, Professor of Chemistry.

THE ST. GOTTHARD RAILWAY is to be purchased by the Swiss Federal government, according to notice given by the government in February of this year.

THE INSTITUTION OF CIVIL ENGINEERS of Great Britain, according to the report of its Council, recently issued, has now a total membership in all grades of nearly 7,500. Of these only a little over 2,000 are full members, over 4,000 are associate members and there are a little over 1,000 students. The annual income of the institution is over $100,000 and it owns real estate and securities valued at nearly a million dollars.

STEAM TURBINES have been finally decided upon by the Cunard Line for the new Atlantic steamers which that company is building. The decision was reached after a very careful investigation of the comparative merits of reciprocating and turbine engines by a technical commission. The report of the commission seems to have been favorable to the turbine engines. The vessels in question are built under subsidy from the British government. The question of using steam turbines in warships has also been considered by the United States Navy, but so far as is known no decision has yet been reached.

THE OIL-BURNING STEAMSHIP "NEBRASKEAN," of the Hawaiian Steamship Co., reached New York on March 27, from San Diego, Cal., by way of Cape Horn. The vessel made the voyage of 12,724 miles in 51 d., 7 h., 22 m., averaging a speed of 10.35 knots; only one stop was made—at Puntas Arenas, in the Straits of Magellan. All records as to her actual performance are withheld for the present. But, according to press statements, the trip was made with the consumption of 9,300 barrels of crude California oil; a main tank, extending from the keel to the main deck, and reserve tanks in the double hull of the ship, carried 10,500 barrels of oil. The "Nebraskean" is the first oil-burning steamship to pass through the Straits of Magellan; but the same vessel had previously been running for 16 months between San Francisco and Honolulu, making the voyage of 2,100 miles in 7½ days. Naval experts will examine and report upon this performance for the Navy Department. The three furnace men, attending to the oil-spraying pumps, did the work of 12 stokers in a coal-consuming steamship, to say nothing of the cargo space saved by the smaller bulk of the oil fuel.

THE PERMANENT INTERNATIONAL ASSOCIATION, of Navigation Congresses, with headquarters at 38 Rue de Louvain, Brussels, has issued a circular giving a history of the associations, including its objects, methods and organization, list of members, etc. Preparations are being made for the next Congress, to be held at Milan, Italy, in 1905. The United States members of the Permanent International Association are Col. Charles W. Raymond, Major Harry F. Hodges and Major James C. Sanford, all of the Engineer Corps, U. S. Army, and Elmer L. Corthell and John Bogart, Members of the American Society of Civil Engineers. Any queries addressed to Col. Raymond, Army Building, 39 Whitehall St., New York city, will receive prompt attention.

SEXTUPLE EFFECT WATER DISTILLING APPARATUS with an efficiency of 45 lbs. of water per lb. of coal has been built for the Egyptian Government by the Mirlees-Watson Co., of Glasgow, Scotland. The plant, as described in "The Engineer" of March 4, will consist of two units each with a daily capacity of 350 tons of water per day. The apparatus is to be erected at Suakimon, on the Red Sea, at a point where the rainfall is almost nothing and fresh water can only be obtained by distillation. The pressures in the evaporators range from 40 lbs. on the first effect to 27 ins. vacuum in the last. A continuous flow is maintained through the apparatus and the seawater taken in at one end is discharged as concentrated brine, reduced to one-fourth its original volume at the other end. This plant is claimed to be the largest distilling apparatus ever made.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see pages 26-27. New copy for standing advertisements should be received ten days in advance of publication; new advertisements, Monday morning. The pages containing "Want" advertisements are held open until Tuesday, and those with "Proposal" and "For Sale" advertisements until Wednesday at 11 a. m.

A correspondent calls attention to the disparity between prices of standard section steel rails, which are held by the rail pool at a uniform price of $28 per ton, and the prices of light section rails which, since the drop in prices of iron and steel products last year, have been sold at an average price of about $23 per ton at Pittsburg. Thus the light rail is sold for about $5 per ton less than the standard rail, notwithstanding the fact that it costs the rolling mill several dollars a ton more to roll the lighter sections.

Our correspondent suggests that one cause of this disparity is that the mills are making use of the rerolling system and are rerolling rejected standard section rails and odds and ends of billets into light sections. It seems probable, however, that the chief reason of the disparity in price is a commercial one. There are, comparatively speaking, very few steel rail mills capable of producing standard section rails and these are controlled by a much smaller number of companies. The maintenance of a price on these rails is, therefore, comparatively easy. The mills capable of rolling light section rails, on the other hand, are quite numerous, and an effective combination between them would be difficult. More important still, the volume of business done in light rails is very closely dependent on the price at which they can be sold. These rails are used for contractors' work, logging roads, industrial railways, short spur lines and similar locations where speeds are low and the matter of safety does not enter. In many cases the use of second-hand rails is an alternative, and one which will be taken advantage of if the price of new rails goes up. This fact is fully understood by steel rail makers, and is doubtless one reason why the maintenance of a pool price on this class of steel products is not attempted.

The problem of indexing the atlas sheets of the U. S. Geological Survey has been neatly solved by Mr. Wm. Pierson Judson, Deputy State Engineer of New York. The state of New York is divided off into rectangles, each corresponding to the standard atlas sheet, and numbered consecutively from 1 to 260. A "progress map" has been printed, on which appear these 260 rectangles, consecutively numbered and marked with appropriate symbols, to show at a glance the progress of the survey. Each rectangle that has already been surveyed has its distinctive name, generally taken from some city, lake or other topographic feature. When the atlas sheets are purchased from the U. S. G. S. at Washington, each sheet must be numbered in its upper left-hand corner with its proper number corresponding to the number of the rectangle on the "progress map." For the purpose of numbering the atlas sheets neatly, Mr. Judson uses Denison's consecutive numbers, which come in perforated sheets gummed on the back, like sheets of postage stamps. Three hundred of Style No. 20 of these numbers can be purchased for 24 cts. from any book-seller.

One of the small (8 × 10 ins.) "progress maps," or index maps as they may now be called, can be had by writing to the New York State Engineer at any time; hence at practically no cost a perfect and simple system of indexing may be had without attempting a cumbersome alphabetical arrangement of the sheets.

It is interesting to note that 55% of the state has been mapped, so that for a nominal sum excellent contour maps of the greater portion of the state may be obtained. Except for a small area, mostly in the northern part of the state, the entire area is marked as being "controlled by triangulation." We may therefore hope that in a few years there will not be an atlas sheet missing out of the whole number of 260. The usefulness of these maps to projectors of railway lines, to engineers designing water supply systems, and the like, cannot be overestimated.

Recurring to the indexing of the U. S. Geological Survey atlas sheets, it would appear that every state in the Union might with advantage be indexed in the way just described, and, in fact, wherever a considerable area is mapped upon separate sheets this numerical system used with a small index map possesses decided merit.

Mayor McClellan, of New York City, has vetoed a legislative bill which sought to legitimatize any encroachment of a building beyond the street line, provided the city does not institute legal action against the encroachment within a year. The veto is gratifying because it represents an unsual recognition of the public importance of street and sidewalk rights. The reasons given for the veto are two:

> First, that of preserving to the city title to its property, and second, that of preserving to the traveling public free and uninterrupted access to and use of all parts of the public streets.

The second of these reasons contains an evident appreciation of the necessity of carefully guarding the rights of sidewalk traffic (as distinguished from the roadway traffic of a street). Such appreciation, especially on the part of public officials, is so rare that it deserves special notice and commendation. The present case shares distinction with a recommendation made by a municipal commission appointed in Baltimore after the recent conflagration in that city to suggest suitable principles to control the rebuilding of the burned district. That commission recommended, among other things, that the practice of permitting encroachment on, and obstruction of, the sidewalks by parts of buildings, such as stoops, storm doors, show-windows, etc., be greatly restricted, to the end that obstruction of the sidewalk space be reduced to a minimum. The reason given was that in the past such obstruction, particularly in the busy part of the city, had grown to a point where the legitimate use of the sidewalk was seriously interfered with, creating a condition of congestion which was harmful to the city in general and particularly harmful to the district in which this congestion occurred.

The veto-message of Mayor McClellan, while not openly admitting that such effects have actually been produced in the past, yet recognizes their possibility:

> In view of the generally crowded condition of our streets, it would be particularly inadvisable . . . to permit any part of the public . . . to make permanent encroachments, no matter how small, upon the line of the streets, for every encroachment, no matter how slight, would . . . constitute a serious deprivation to the general public, whose rights extend to each and every part of the public streets.

Though this reasoning is apparently quite abstract, yet it may fairly be taken to imply that "serious deprivation to the general public" in this way has occurred in the past, at least to an extent which would make necessary a greater care in the future.

That the public's right of free access to all parts of the sidewalk space is violated and infringed upon to a very great extent in the busier sections of all cities, is a most evident fact. The older cities of the country, and in general the oldest portions of cities, exhibit this most strikingly. Narrow streets carrying heavy traffic are obstructed with as little consideration of the rights of the public as the wider streets. As an instance, only a few steps from the offices of this journal, a seven-foot sidewalk in a narrow street carrying a heavy traffic through the day, has recently been obstructed by a ventilator head fully 3 ft. wide, thus narrowing the already inadequate sidewalk by almost one-third. Remedies for such obstruction exist in every city, probably in the shape of laws and ordinances, but these do not seem to be adequately or intelligently enforced.

The tendency of the average man is to consider chiefly the property owner whose interests can be expressed in dollars and cents and to overlook the interests of the tens of thousands who use the sidewalk because the inconvenience to any single pedestrian is infinitesimal. When one takes a broader view of the question, however, it becomes clear that the paramount interest is that of the general public in maintaining adequate facilities for traffic through the streets.

Encroachment on the surface of the sidewalk, though the most obvious, is not the only infringement on this important division of the street. Overhead encroachment by cornices and belt-courses of buildings, by porticos and marquees, while it does not directly interfere with traffic, often materially reduces the access of light and air to the street. More important still is the subsurface encroachment by vaults under the sidewalk. This is so universal and meets with so little opposition that it seems as though the rights of the public to this space were practically ignored. It is perhaps true that under present conditions this space in most cases is of little value to the public. But it might easily be made of great value if it were properly utilized for carrying the collection of pipes and conduits which is now carried under the roadway pavement. With the ever-increasing use of expensive permanent pavements, especially sheet-asphalt, these pipes and conduits create endless trouble and cut down the life of the pavement by a large amount. Were they located under the sidewalks, in the space now appropriated for extension of the abutting buildings, these troubles would be greatly reduced and when conditions warrant the construction of pipe galleries, these would be most suitably located in this very space.

The value of the sidewalk space, underground, surface and overhead, to-day but little appreciated, can hardly fail to receive greater recognition in the future. The traffic in the business districts of the larger cities has reached a point where obstructions to its flow from any cause mean serious public loss. It is on this account that the rare cases where the importance of the subject is officially recognized, such as the two cases cited, deserve public commendation.

FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVES.

Within the past few years there has been a rather remarkable development of the four-cylinder balanced type of compound locomotive in Europe, especially in France and Germany, and this type of compound engine has also been given some attention in this country. Some experimental engines have been built here, others have more recently been put in service, and a French locomotive of the design now extensively used abroad has been purchased by the Pennsylvania R. R. It is, therefore, appropriate at the present time to give some consideration to this particular type of the compound locomotive.

The greatest practical development of the compound locomotive has been in this country, and with the Vauclain system, which was first introduced in 1890 (Eng. News, May 3, Sept. 6 and

Sept. 13, 1890), and which has since been applied to 2,867 engines built by the Baldwin Locomotive Works for American and foreign railways. This number is probably greater than that of all the compound engines of all other types put together, in this country and abroad. The total number of compound engines built by this firm up to the present time is as follows: 2,867 Vauclain four-cylinder, 5 four-cylinder balanced, 71 four-cylinder tandem, and 43 two-cylinder cross-compound, or 2,986 in all. The tandem compounds (Engineering News, April 24, 1902) have advantages for heavy freight service and have given good results under severe conditions. In the original Vauclain system there are two pairs of outside cylinders on each side, the two cylinders of each pair being placed one above the other, and having the two piston rods of each pair connected to a single cross-head and connecting rod. The power from the two cylinders is thus transmitted to one crank-pin, as in the case of a simple engine or a two-cylinder compound. The same is true of the four-cylinder tandem compound locomotives, of which a number have been built.

The feature of the four-cylinder balanced compound, however, which distinguishes it from other types of four-cylinder compounds, is that each of the four cylinders has its own cross-head, connecting rod and crank. Two of the cylinders are placed inside and drive a crank axle. In some designs, all the cylinders drive one axle, while in other designs the high-pressure cylinders drive one axle and the low-pressure cylinders drive another. With the four cylinders, and with cranks placed at suitable angles, there is a more uniform turning movement. The special advantage, however, lies in the fact that the weights of the reciprocating parts of one pair of cylinders may be made to balance those of the other pair, thus eliminating the necessity of using counterweights in the driving wheels to balance these reciprocating weights. Only the revolving weights remain to be balanced, and this is a comparatively simple matter.

In the ordinary locomotive, as is well known, the reciprocating weights are partially balanced by the addition of metal counterweights in the wheels, but all the weight thus added is wholly unbalanced so far as its vertical motion is concerned, and produces a so-called "hammer blow" upon the rail. If the reciprocating parts were wholly unbalanced, there would be a fore and aft vibration and "nosing" which would make the locomotive uncomfortable to ride on and unsafe. If the reciprocating parts were fully balanced by counterweights in the driving wheels, this whole weight would produce an additional stress on the rail at every revolution equal to its centrifugal force, and the locomotive would "roll" badly on its springs. In practice the locomotive designer has to steer between these two extremes and make a machine unbalanced both vertically and horizontally.

With the small locomotives and moderate speeds which were the rule in the early days of railroading, the matter of balancing was comparatively unimportant. With the heavy high speed engines of the present day, having reciprocating parts weighing perhaps over 700 lbs. on each side, the problem of satisfactory counterbalancing is very serious indeed.

Another point of no small practical importance in these days when there is a continual demand for increased traction by locomotives, is that the limit of driving wheel loads is fixed not by the static weight on the wheel, but by this weight plus the effect of the hammer blow due to the unbalanced portion of the counterweight. With complete balancing and the consequent elimination of excessive and abnormal irregular loads upon the rails, the tractive power could be increased by increasing the weight upon the driving wheels.

When the four-cylinder balanced compound was first suggested, it received severe criticism on the score of its complication in general and of its crank axle in particular. In regard to complication, in an editorial on "Compound Locomotives" in our issue of March 8, 1890, we pointed out that while one thing to be aimed at is simplicity in the design and arrangement of parts, yet simplicity means not merely a minimum number of parts, but includes also a reliable and durable construction and arrangement, in order to secure economical results. On this point also the following remarks from an address on "Possibilities in American Locomotive Design," delivered by Prof. W. F. M. Goss, in 1902, put the matter in its right light:

> We do not really object to complication, but rather to things which are bad. A bad contrivance may be complicated, and may be objected to, and properly so, but we should not deceive ourselves as to the cause of its defects. A careful analysis will in most cases show that the real objection is not due to complication, but to the inherent badness of design, and this, it goes without saying, should always be condemned. It is not too much to say with reference to the details of locomotive design and construction, that increased complication in parts which are well conceived and well designed, cannot in any way impair the efficiency of the whole machine or increase its chance of becoming deranged. On the other hand, if, by increasing complication, a necessary function can be better performed, then it may often happen that danger of derangement is lessened and the action of the whole machine is actually improved. The sulky plow is more complicated than the crooked stick of the Egyptian, the steam saw mill than the whip-saw, and the ocean liner than the primitive raft or canoe. But in all these cases, the results sought are secured with greater certainty and with a higher degree of perfection, by the more complicated mechanisms. So long as designers can conceive of better results, just so long will they strive for changes and additions that such results may be secured. I have no argument in favor of complication for complication's sake. The argument is to the effect that a really good device is good, notwithstanding the fact that it may be complicated.

As to the use of crank axles, in view of the extensive and successful use of such axles on European railways for many years, and in view of the remarkable development in steel manufacture, we see no reason why this should necessarily be a weak point in locomotive design. There may be some ingenuity required in obtaining sufficient bearing surface, as indicated by the experience on the engines of the Atchison, Topeka & Santa Fe Ry., noted below, but here again European practice indicates that this difficulty may be easily overcome.

The Shaw locomotive, designed some 20 years ago, was one of the first experiments made in this country in the balancing of engines by the use of four cylinders, but no practical results followed. In this engine, all the cylinders were outside. Later on, the Ball balanced compound engine was designed, but we do not know that it was ever put in service. This also had the peculiarity of four outside cylinders, the cylinders being tandem, but offset laterally so that the long piston rod of the low-pressure cylinder lies besides the high-pressure cylinder. The connecting rod of the latter drives the usual crank pin in the wheel, while that of the high pressure drives a return crank. The cranks on each side are placed at 180° with each other, and at 90° with those on the other side. In 1897, Mr. Geo. S. Strong had an Atlantic (or 4-4-2) engine altered to his designs, in which the two high-pressure inside cylinders and the low-pressure outside cylinders were all connected to the first driving axle. The reciprocating parts of the two sets of cylinders balanced each other, so that only the revolving weights had to be balanced by weights on the wheels. These weights were distributed partly near the rim and partly near the hub. This engine had three vertical gridiron valves to each cylinder, operated by a modification of the Walschaert valve gear, so arranged as to make the cut-off and exhaust of the high-pressure independent of those of the low-pressure cylinders. The engine was tested at Purdue University, but there the matter seems to have ended, and the "balanced-engine" idea in this country slumbered until 1902. In that year the Baldwin Locomotive Works built for the Plant System, at the suggestion of Mr. Symons, Superintendent of Motive Power, a four-cylinder balanced compound, having all the cylinders connected to the first driving axle, as in the Van Borries system used in Germany. The high-pressure cylinders, however, were inside, while the general practice is to put them outside. The engine was of the ten-wheel type (Eng. News, March 13, 1902), but with the first instead of the second axle made the main driving axle, as necessitated by the inside connections. This engine is now owned by the Wheeling & Lake Erie Ry. In 1903, the same builders completed four Atlantic engines on the same system for the Atchison, Topeka & Santa Fe Ry., and these are described in another part of this issue. In 1903, also, the Pennsylvania R. R. ordered from France an Atlantic engine of the De Glehn type, in which the power is transmitted directly to two of the axles, as shown in a descriptive article in this issue.

In England, three-cylinder compounds, with inside and outside cylinders connected to separate axles, were first introduced on the London & Northwestern Ry. by Mr. F. W. Webb, in 1881, and up to 1893 about 200 of these had been built. In these engines no coupling rods were used, and a similar arrangement was adopted on the London & Southwestern Ry., in 1898, for four-cylinder simple engines. In 1897, Mr. Webb built for the first-named road, several four-cylinder simple and compound eight-wheel (4-4-0) engines, having all the cylinders connected to one axle, which of course necessitated the use of coupling rods. (Engineering News, Jan. 6, 1898.) They also had one set of valve gear to each pair of cylinders; the valve stems extended through the front covers of the steam chests and the high-pressure valve was driven from the low-pressure valve stem by means of a lever. A three-cylinder eight-coupled freight engine, with all cylinders connected to one axle, was built by Mr. Webb in 1893. We learn, however, that the three-cylinder engines, once so generally used on this road, have been practically superseded by the four-cylinder engines on all important trains.

In France, there has been a very remarkable development in the use of four-cylinder balanced compounds within the past few years, more especially for passenger service, and their performance in maintaining continued high speed with heavy trains has been equally remarkable. Most of the engines are passenger locomotives of the Atlantic type, but the system has also been applied to ten-wheel and consolidation engines. The De Glehn system, of which so much is now heard, was brought out in 1895, and was taken up first by the Northern Ry., whose engines of 1896 were the first having four cylinders connected to two axles. This road now has a number of eight-wheel and Atlantic engines and nearly 200 ten-wheel engines on this system. Some of our readers may remember the eight-wheel four-cylinder engine exhibited by the Northern Ry. at the Columbian Exhibition, Chicago, in 1893; and in our issue of June 13, 1895, we illustrated a four-cylinder consolidation engine of the Paris, Lyons & Mediterranean Ry. This road began using the system on eight-wheel engines in 1889, Mr. Henry putting the high-pressure cylinders inside, but his successor, Mr. Beaudry, has followed the more usual practice of putting these cylinders outside. In 1900 this latter road had nearly 200 four-cylinder engines with cylinders connected to two axles, and over 30 with cylinders connected to one axle.

On many of the engines of the Paris, Lyons & Mediterranean Ry. the Walschaert valve gear is used for the outside cylinders, and the Stephenson gear (with four eccentrics) for the inside cylinders. Mr. De Glehn, however, uses the Walschaert gear for both outside and inside cylinders, the latter being of necessity driven from an eccentric instead of a return crank. In this arrangement only two eccentrics are required instead of four.

In a paper on locomotive practice in France, presented before the Institution of Mechanical Engineers (of England) in 1900, by Mr. Edward Sauvage, Assistant Superintendent of Motive Power, of the Western Ry. of France, it was pointed out that four-cylinder compound engines had been practically adopted as standards by several of the leading French railways. There were then over 800 in use, but of these four were of the Vauclain system with superimposed cylinders, and 20 were of the Woolf system with tandem cylinders. Coupling rods were used in almost every case. In the three years since that paper was read the number of engines of this type has increased enormously, and there are now over 1,500 of the De Glehn type alone. At the Paris Exhibition of 1900, out of 36 compound locomo-

tives, 18 were of the four-cylinder type, and 15 of these were balanced. The engines were classified as follows: A, with two coupled axles (De Glehn), 9; B, with two uncoupled axles (Mallet), 3; C, with all cylinders driving one axle, 3; D, four-cylinder tandem, 1; E, four-cylinder Vauclain, 1; F, four-cylinder with two separate groups of wheels (rack and adhesion), 1. Geographically, the distribution was as follows: France, 8; Germany, 4; Russia, 2; and one each for England, Hungary, Italy and Switzerland.

In Germany, several of the State railways are using four-cylinder balanced compounds, principally of the Atlantic type. In Switzerland the Jura-Simplon Ry. and the Gotthard Ry. have these engines of the ten-wheel type (Eng. News, Sept. 12, 1895). In Italy the Southern Ry. has about 20 engines of the ten-wheel type in which the cab is over the truck and the cylinders are at the rear end of the frame. These latter have the outside cranks set at 180° to the inside cranks, and consequently the steam passages are crossed, the opposite ends of the two connected cylinders being in constant communication. Two sets of valve gear serve the four cylinders.

The De Glehn system originated in 1895 with Mr. Alfred De Glehn, Managing Director of the Societe Alsacienne de Constructions Mecaniques, and it was developed largely in conjunction with Mr. Du Bosquet, Superintendent of Motive Power of the Northern Ry., of France. In a paper written for "The Engineer" (London) in October, 1903, Mr. De Glehn stated that about 1,500 of his engines were then in service or under construction. The essential features of the design are as follows: (1) The high-pressure cylinders drive one axle and the low-pressure cylinders drive another, the coupling rods between these wheels serving mainly to maintain the proper relative positions of the crank pins. (2) For each cylinder there is a valve and valve gear, with the usual reversing shaft, the two shafts being worked together or separately from the screw reversing gear, so that the lead of the two sets of cylinders can be varied at will. (3) The engine can be converted into a four-cylinder simple engine by admitting steam into the low-pressure cylinders, while at the same time a valve opens the high-pressure exhaust to the main exhaust. The advantages claimed are particularly in the division of stresses and the balancing of the reciprocating weights, leaving only the revolving weights to be balanced by counterweights in the wheels.

Mr. Von Borries, of the Prussian State Railways, introduced a four-cylinder balanced arrangement with the four cylinders in a row, all driving one axle. Each cylinder has its own valve but there is only a single valve gear on each side, operating the high and low-pressure valves by means of a rocking shaft arrangement, which gives different but fixed ratios of expansion in the high-pressure and low-pressure cylinders. The use of the two valves is in order to allow of varying the cut-off independently, thus effecting better steam distribution, the cut-off being generally 0.3 to 0.4% in the high-pressure cylinder, but both valves of each pair of cylinders are operated from one valve gear, the valve stems being connected to a lever driven from the link. In the new Vauclain four-cylinder balanced system, however, there is further simplification by the use of a single piston valve to each pair of cylinders, and the builders are of opinion that in practice equally good results are obtained. This system also follows the Von Borries system in connecting all the cylinders to one axle, for the reason that this arrangement avoids the abnormal length of the parts and insures better counterbalancing.

In regard to these modifications, Mr. De Glehn does not approve of connecting all cylinders to one axle, and using one valve gear to two cylinders, as it throws excessive stress on the crank axle and valve gear. Mr. Von Borries, however, replies to this by saying that the cranked portion of the axle receives only the stresses due to the inside cylinders, the stresses from the outside high-pressure cylinders being taken up and transmitted largely by the coupling rods. Thus the crank axle of a Von Borries engine is stressed but little more than that of a De Glehn engine, while the wear on driving boxes is claimed to be less, since the stresses on the boxes are better balanced. Nor does Mr. De Glehn approve of a single valve for two cylinders, as in the Vauclain balanced engines described in another column, as he thinks the valve will be hard to move if tight, or leaky if made easy-moving. He considers also that the Von Borries single valve-gear for two valves is objectionable, as it involves a fixed ratio between the expansions in the two cylinders, which gives less adaptability to the varying conditions when the engine is running. In fact, he attributes much of the success of his engines to the duplex arrangement of the valve gear, by which the point of cut-off can be varied independently and at will in the high-pressure and low-pressure cylinders. A similar arrangement has been used on some four-cylinder compounds on the London & Northwestern Ry. The high and low-pressure reversing rods are attached adjustably to a cross-head or slide worked by the reversing screw, and the results in tests and in service are said to have shown that there was a distinct gain in power and that the double valve gear was not objectionably complicated.

On the other hand, Mr. Von Borries thinks that the enginemen are not capable of using the independent cut-off to advantage, and that it is better to fix the proportions of expansion at the best value for the ordinary running notch, and to lose a little when running occasionally with the lever in the extreme notches. He also prefers piston valves for the high-pressure cylinders, and sees no objection to using a single-link motion to drive the high-pressure piston valve and the low-pressure slide valve. His system is in somewhat extensive use on the State Railways of Prussia, Baden, Bavaria, Austria and Hungary, the engines being mainly of the Atlantic type.

As to fuel economy and cost of maintenance, Mr. Salomon, of the Western Ry. of France, has stated that the four-cylinder balanced compounds of the De Glehn system have shown economical results as compared with two-cylinder engines. The better distribution of power leads to reduction in wear of the moving parts, and the fuel economy averaged about 12%. The tires made 36,000 miles between the times they were re-turned, while those of the other engines made only 32,000 miles. And while the valves of simple engines with 170 lbs. pressure gave a service of 43,000 miles, those of the compounds (with 200 lbs. pressure) made 128,000 to 206,000 miles for the high pressure, and 193,000 to 225,000 miles for the low pressure. Mr. Von Borries gives the following figures of mileage between turnings of tires: Simple engines, average during 11 years, 23,000 miles; two-cylinder compounds, during 9 years, 29,200 miles; Von Borries four-cylinder compounds, during 2 years, 44,200 miles; De Glehn four-cylinder compounds, during 8 years, 25,200 miles.

It is certain that as far as European practice is concerned the four-cylinder balanced compound has established its practical efficiency in the test of extensive regular service, both in regard to the number of engines and the length of time they have been in service. In this country it remains to be seen whether it will be best to vary the steam distribution at the expense of an increase in number of parts, or to simplify the construction at the expense of flexibility in the steam distribution to suit varying conditions. There will very soon be some practical experience with the two types, as follows: Vauclain, four cylinders driving one axle, with two valves, two valve-gears; De Glehn, four cylinders driving two axles, with four valves and four valve-gears. As both of these engines are to be operated on the testing plant at St. Louis we may look for interesting results without waiting for records of service on the road.

LETTERS TO THE EDITOR.

An Asbestos Backing Suggested for Rolling Fireproof Shutters.

Sir: In your editorial of March 17 you speak of the difficulty of applying fireproof shutters to buildings, especially to their fronts. Speaking of rolling shutters you say that none so far devised seem to give much protection. I would suggest the possibility of using asbestos curtains at the back of the shutters, either separately or attached to them. I presume one great trouble is the openings and crevices in the rolling shutter. With a little pains an asbestos curtain might be made to lap and fit quite closely. If two could be used with an air space between much better results might be got.

Truly yours, Chas. H. Scott.

Elkins, W. Va., March 21, 1904.

The Rapidity of Construction of Raymond Concrete Piles.

Sir: Referring to the article in your issue of March 10, 1904, entitled "The Construction and Use of Concrete Steel Piles in Foundation Work," the writer thinks that the Raymond pile was hardly given the consideration it deserves. It seems quite evident that the author was not familiar, at least from personal observation, with the piles put in under that system. He says: "The apparatus employed in constructing Raymond concrete steel piles is of rather elaborate character." This naturally leads the reader to infer that the process is therefore a slow one. The contrary is shown to be the case, when it is learned that 15 concrete piles, 20 ft. in length and 20 ins. in diameter at top and 6 ins. at the bottom, were driven, filled and completed in 2½ hours with one ordinary pile driver at Schenectady, N. Y., which is an average of one completed pile every ten minutes. The soil was rather a soft fill, but the piles, which did not reach any hard material, were weighted with from 32,000 to 48,000 lbs. without settlement. If straight piles had been used much longer ones would have been required, as they would necessarily have depended almost entirely upon the point to carry the load. With this tapering Raymond pile, the ground is pressed out and packed with every blow, instead of merely making a hole and following the hole. This work was done for the Mohawk Gas Co. and was for the foundation of a gas holder 109 ft. 6 ins. in diameter; 689, 20-ft. concrete piles were used. This work was done in competition with wooden piling construction and resulted in a marked saving. Yours truly,

H. R. Moyer,
Treasurer, Raymond Concrete Pile Co.

135 Adams St., Chicago, Ill., March 12, 1904.

Cement Handling in the Darlington Building; A Correction.

Sir: We note, with some regret, that in the editorial of your issue of March 24, on pages 281 and 282, references are made to the storage of cement and cinder on the upper floors during the construction of the Hotel Darlington. We wish to state that the current newspaper reports on this disaster have repeatedly contained this statement, and that it has done us a material injustice, inasmuch as we never store any materials on the upper floors in any of our work.

All of our cement, cinder, sand, etc., is dumped into the basement of all buildings, and the mixing is done on a platform in the basement. After the concrete is mixed, it is hoisted in wheelbarrow loads to the desired floor levels, and then placed in position by wheeling the barrows and dumping the concrete into the arches. This is the universal practice with us, and it was strictly followed out in the work at the Hotel Darlington. We regret that this misstatement of the facts should have been dwelt on at such considerable length, in at least five places in your editorial, when, as a matter of fact, there was absolutely no cement or cinder on any of the floors except such as was in the concrete, and part of the fireproof construction.

The testimony in the investigation showed, however, that there was steel stored in the upper tiers, in which respect the editorial is entirely correct, and the criticisms that you make are excellent. We must, however, plead "not guilty" and regret that your editorial statements, which are ordinarily strictly exact, proved to be in error in this particular case. Yours truly,

A. L. A. Himmelwright.
The Roebling Construction Co.,

Fuller Bldg., New York, N. Y., March 24, 1904.

The Stresses in the Milford, Ohio, Concrete-Steel Stand-Pipe.

Sir: In Engineering News of Feb. 25, there appears a description of a reinforced concrete stand-pipe built at Milford, Ohio, having an outside diameter of 15 ft. 6 ins. and a height of 81 ft. The inside diameter at the base is 14 ft., and the lower 30 ft. of the structure is reinforced with 1 × 1 × ⅛-in. T-bars spaced six to the foot. The water pressure near the base, under a head of 78 ft. of water, would be 78 × 62.4 = 4,867 lbs. per sq. ft. This pressure produces a rim tension of 34,060 lbs. per vertical foot of the shell, and is resisted by the T-bars with such assistance from the concrete as may be. Owing to the danger of the concrete being seriously stressed by unequal settling of the foundations, and to the uncertainty as to the tensile strength of concrete, it is hardly safe to consider anything but the steel as taking up the tension stress due to water pressure. The area of one 1 × 1 × ⅛-in. T-bar is 0.26 sq. in. If these T-bars are securely spliced so that all six may equally resist the stress, there is a tensile stress in the steel equal to 34,060 ÷ 6 × 0.26 = 21,839 lbs. per sq. in. If they are not spliced but break joints,

so that only one bar is lost in a vertical foot, the tensile stress in the steel is $34{,}000 \times 5 \times 0.26 = 26{,}207$ lbs. per sq. in. For a steel stand-pipe not over 15,000 lbs. per sq. in. would be considered a safe unit stress in the shell plates. Without a more complete description than has been given, it is uncertain how the T-bars have been connected and hence the stresses per square inch may even be greater than the above. In any case they cannot be considered less, unless an allowance is made for the tensile strength of the concrete wall. If this is assumed as 50 lbs. per sq. in. or $9 \times 12 \times 50 = 5{,}400$ lbs., it would reduce the stresses in the steel about 16% leaving stresses of 18,376 to 22,052 lbs. per sq. in. for six or five bars. It is perhaps needless to say that other stresses besides those due to direct pressure of water must be considered in stand-pipe designs, such as wind and frost.

In view of the serious consequences that have attended stand-pipe failures over the country, the reckless designing of steel plate stand-pipes came to an end some years ago, and low unit stresses were adopted as the only safe rule for designing such structures.

While reinforced concrete is an excellent and economical material for a great variety of structures, it is important that the same engineering care and judgment be exercised in designing such structures as is required for steel structures.

Yours truly,
T. L. Condron, M. Am. Soc. C. E.

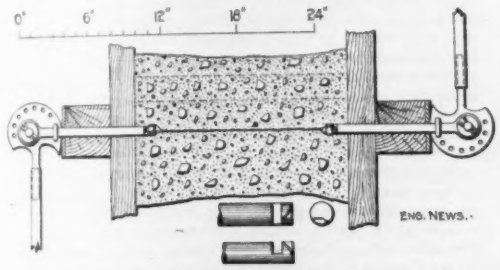
1750 Monadnock Block, Chicago, Ill., March 4, 1904.

A New Concrete Wall Mold Clamp and Tie.

Sir: In your issue of Jan. 28, 1904, I notice an article on the ties employed for holding concrete forms in place by the Chicago, Milwaukee & St. Paul Ry. A rod threaded at each end, with a cast nut in the concrete over which wire hooks, is used.

As considerable expense is attached to the proper holding of forms in concrete construction, I have, in the construction of the Louisville & Nashville R. R. Co.'s new shops at South Louisville used a clamp successfully for some time and for which patents are now pending.

The advantage in this arrangement is, that there are



Clamp and Tie for Wall Molds for Concrete Work.

no threaded bolts or nuts or wrench to use in putting together or taking forms down. The clamp is made of malleable iron and is put through the form and a twisted wire of the desired strength is placed on the hook. The cam is then turned, by placing a 2-ft. piece of gas pipe on the handle for leverage, to the desired tension on the strut, which is the length of the wall or pier. The concrete is then placed in the form and thoroughly tamped.

To release the forms it is only necessary to release the cam and turn it bottom side up, when the I-bolt is at once released from the wire tie and the clamp can be immediately removed, leaving the wire tie in the concrete. The form is then taken down and the hole left by the I-bolt is filled with cement. The wire tie left in the concrete is no loss in this work, as all of our walls and piers are reinforced with wire, rods, expanded metal, etc.

There is no question as to the practicability of reinforced concrete in construction. There are, however, many ways of reinforcing, some good and some bad. In the main, reinforced concrete construction is beyond the experimental stage and is now a matter of cost and construction, hence this clamp for holding forms in place.

Yours respectfully, J. C. Van Natta,
Asst. Engineer, L. & N. R. R.

Louisville, Ky., March 4, 1904.

Approving Short Tripods.

Sir: On the subject of short tripods mentioned in letter of W. H. Hendricks in your issue of March 17, it may be of interest to record my own experience with a tripod even shorter than the one described.

In executing triangulation work of more or less accuracy in the harbors of Lake Erie, I have recently used a Buff & Berger transit of ordinary size and design, reading by vernier to 30 ins. and easily by estimation to 15 ins. The work since 1892 has all been done by repetition method, which, considering all conditions, seems better adapted to the work than the direction method. Sometimes the instrument was set up on ground, but generally on a regularly built station with instrument 8 to 12 ft. above ground. Tripod and platform were built of 4-in. by 4-in. timber, dressed and painted for preservation. With the built tripod, it is customary to use a "trivet" upon which the instrument is placed after centering, but it was decided to use, instead, a set of short legs which could be readily attached to the tripod head in place of the long ones, alternating to meet the requirements; it was more easily carried than a trivet. The spread of the short legs is about the same as that of the points of trivet, 6 to 8 ins., so that it can be placed firmly upon the head of the built tripod.

The design is similar to that shown in Mr. Hendricks' sketch, but the entire length of leg is only *nine inches*. It is turned from a solid piece 2¼ ins. diameter and tapers to 1¼ ins., at head of steel point. Through the middle of the leg a saw-slot is made about 1¾ ins. long to allow of close binding on the head, by the thumb-screws. The tripod is driven into the built tripod by hammering on the legs attached to steel point, after centering over the mark, the accurate centering being done by movable head of instrument after hammering has ceased.

Referring to the accuracy of work, it is fully equal to that obtained by use of the trivet or long legs. With triangle sides of from a half mile to five miles length, there is no difficulty at all (so far as this attachment is concerned) in closing triangles within 3 ins., using two sets of six repetitions each, reading at the close of each six, and taking negative readings in the same way, returning to the initial reading. Of course, the ordinary precautions are necessary in this as in all close work, such as protection of the built tripod and instrument from sun and wind, equal number of pointings direct and reverse, etc. In the triangulation of Sandusky Bay and of Maumee Bay and River, about sixty triangles were observed, and in only a very few of them was the closure greater than 3 ins.

My experience therefore indicates that the short tripod does not in itself introduce any new obstacles to accurate work, and is a very great convenience as interchangeable with the ordinary long legs. Very respectfully,

Wm. T. Blunt, U. S. Assistant Engr.

Toledo, O., March 21, 1904.

The Pressures on Surcharged Masonry Dams.

Sir: The writer was interested in the questions raised by Mr. John C. Trautwine, 3d, in Engineering News of Feb. 11, in regard to surcharged masonry dams. In the discussion by Mr. E. Sherman Gould in Engineering News of March 3 there seem to be two things that might be misleading.

First, in the application of his formula for moment of pressure, $M = P g$. This moment is in foot pounds. Then he divides this by the density of masonry, thus:

$$m = \frac{3.5\ M}{\text{density}} = \frac{3.5\ M}{\frac{135}{\text{weight}}} = 81{,}693 \text{ ft.-lbs.}$$

As density equals $\frac{\text{weight}}{\text{volume}}$, m equals 81,693 vol. × ft. or cu. ft. × ft. instead of ft. lbs.

In the discussion regarding the formation of a vacuum Mr. Gould states that, "The effect of a vacuum even supposing it could be produced would certainly be to draw the sheet of water down to the face of the dam, thus destroying the vacuum as fast as formed." This, it seems to the writer, does not answer the question nor show that it would not seriously affect the stability of the dam. The water might be forced down to follow the face of the dam by the atmospheric pressure and yet the pressure of the water on the face be practically zero, giving the effect of a vacuum on the dam.

If this be true, then, added stability should be given to the dam or the down stream face should be so designed that the falling water will follow without materially reducing the pressure, or perhaps air could be supplied underneath, as suggested by Mr. Trautwine.

Very truly yours, Chas. M. Emmons.

Beaver Falls, Pa., March 15, 1904.

Sir: In reply to Mr. Emmons' criticisms I would say that it would be more strictly accurate, though rather awkward, to express M as "area feet," because it must be balanced by the moment of the area of section of the dam. It could not be expressed in cubic feet. It would be better to leave the value 81,693 as an abstract quantity without giving it any name at all.

If the water is forced down to the face of the dam by atmospheric pressure, it is hard to see how its pressure against the face can be reduced to zero. The danger to be guarded against is the battering impact of the falling water, and also its tendency to undermine the foot of the dam when the bed of the stream is not naturally rock paved. In this case the foot must be protected by a wide and massive apron of cement masonry. The spillway of a dam, or any portion of it which may be subject to overflow, requires sound judgment, both in the general design and in its many details, in order to secure safety without running into uncalled for extravagance. It is just here that the skill of the engineer comes into play; a skill which is the fruit of long experience and observation and which cannot be reduced to a mathematical formula.

E. Sherman Gould.

Yonkers, N. Y., March 18, 1904.

Obtaining the Mean Velocity of Streams.

Sir: Referring to the article in your issue of March 17 on "Methods of Obtaining Mean Velocity of a Cross Section in Gaging Streams," I wish to give methods that have been used on large streams, and which differ somewhat from the ones mentioned by Mr. Robinson. The cross-section of the river is divided into sections of equal horizontal distance, say 200 ft., to facilitate computations; and a velocity station is established at the middle point of each of these sections, and the velocity as found at that station is applied to the particular section. The end sections take up the odd distances, and vary from day to day with the rise or fall of the stream. The velocity for these end sections is taken at a point about midway between the shore and the dividing line for the next section. This will generally give quantities above the correct ones.

The foregoing method is often supplemented by the plotting of what may be called the velocity curve; this can be done on the plotted cross-section of the stream, by assuming any convenient scale and plotting the velocities in feet per second, at each station, in distances below the water surface, or top of section, and then drawing through these points an easy curve, or series of reverse curves, as the case may be, using the ends of the cross-section as points in the curve, the same being zero. From this curve the mean end velocities can be obtained more accurately. For large streams, however, the end velocities and sections are small by comparison and the small differences due to change of methods are well within the degree of accuracy obtainable by current meter measurements.

Very respectfully,

Chas. H. Miller, M. Am. Soc. C. E.

727 E. End Ave., Pittsburg, Pa., March 25, 1904.

Sir: Referring to the letter in your columns of Mar. 17, 1904, from Mr. H. F. Robinson, regarding stream gagings I should like to make the following statement:

I do not use any uniform rule for determining the discharge through the end divisions of river cross-sections, but consider each case separately. When the edges of the river cross-sections are bounded by abutments or piers of bridges, I take velocity observations, with the current meter, as near to the abutment or pier as is possible without danger of injuring the meter; even though this point is not at the end of one of the regular divisions of the cross-section. It is then easy to tell, from inspection, and with a sufficient degree of accuracy for the purpose, what relation the velocity at the abutment or pier bears to the velocity, determined with the current meter a short distance away.

The velocity may decrease gradually from the last point of observation to zero at the abutment, or the velocity at these two points may be practically the same. Frequently the flow is so diverted by the upstream ends of the abutments or piers that the edge of the current under the bridge is at some distance from them and its position may be easily determined. In this latter case, however, there may be a cross current action produced, over a distance of a few feet, which should be allowed for in computing.

Where the river section is bounded by natural banks, I take a velocity reading as near the edge of the water as the depth will permit and then estimate the velocity at the edge by comparison with the meter reading. Thus the end divisions are subdivided into two parts through the greater of which the discharge is as accurately determined as in any other regular division of the river cross-section; and any error arising from estimating the flow at the edge of the water will not cause an error in the final result of more than is allowable. It being possible to use a small Price meter in less than 0.5 ft. of water one can usually get a meter reading fairly near to the bank.

As ideal conditions can so rarely be obtained at river gaging stations it is best not to use general rules without first finding out whether they are applicable to the case at hand.

Very truly yours.

R. Winthrop Pratt,
Engineer, Ohio State Board of Health.

Columbus, O., March 20, 1904.

Obtaining the True Meridian by Daylight.

Sir: I wish to call the attention of your readers to a method of obtaining the true meridian by daylight, which I have never seen mentioned in print. In its simplest form, it is this: Find when the sun is exactly south and point the transit at the center of it at that time. In practice, we point to it nearly at the right time and compute the difference. As the sun moves, at the present writing, about 20″ in azimuth in a second of time, it is evident that a watch of known error is essential to precision, and a good map, from which longitude and latitude may be scaled, is also desirable.

For the last four or five years I have amused myself, at odd times, by taking pole-star observations for checking the courses of railroad tangents, and have gained, along with some useful experience, a lively sense of the inconveniences that go with cross-hair lighting, keeping bubbles adjusted and reading angles by lantern light, knocking

about railroad yards after dark, dodging engines, etc. Consequently, when it was suggested that the sun might be used, the idea was promptly accepted, and for the last six weeks we have been practicing it with considerable success. The Coast Survey office, being consulted, gave us a caution as to the limits within which the method should be used, and instructed us as to the method of reducing all our courses to a single meridian.

As the Boston & Maine system lies just west of the 70th meridian, we make a list for every day in the month, showing the time when the center of the sun crosses the 70th meridian, stating it in Eastern standard (75th meridian) time. Then, from a Geological Survey map to which we have added figures showing differences, in time of the earth's rotation, between the various meridians shown and the 70th meridian, we scale off, for the place of observation, the time-correction, which is always plus, and our preliminary computation is as follows:

For observation March 10, 1904:

Transit of sun over 70th meridian in standard time ..	11 hrs.	50 mins.	26 secs.
Correction for longitude	+0 "	4 "	23 "
Correction for fast watch...	+0 "	0 "	12 "
	11 hrs.	55 mins.	1 sec.

For observing, we use a Buff & Berger transit, with an eye-piece attachment, provided with colored glass to tone down the glare of the sun, and with a prism for use when the sun is high. About a minute and a half before the time figured as above, the transit, firmly set and carefully leveled, is pointed so that the sun is wholly in the field of view, and on the left-hand side of it, the plates being clamped at zero. The transitman then watches until he sees the vertical cross-hair just touching the right-hand limb of the sun, when he cries "Now," and the other, who has been following the second-hand of his watch, records the time. The time is taken again when the cross-hair bisects the sun, and when it just touches the sun's left-hand limb in passing off. Then the telescope is swung into the line whose course is required, and the angle read.

As a precaution, we usually take three sets of observations like the above—one 5 or 10 minutes before the meridian transit, one as near it as possible, and a third as soon as may be after the second. In reducing, the times of right-hand and left-hand contact are averaged to get the time when the hair passes the center, the observed bisection being used merely as a check. The velocity of the sun in azimuth is deduced from the difference between the first and third angles, taken in connection with the corresponding number of seconds of time.

The velocity is then checked by computing the second angle from the first, and comparing it with the observed angle; the difference is usually less than half a minute. The velocity adopted is then used in connection with the second angle and the time of second observation to compute the difference in azimuth between the sun's second position and the meridian, and this is applied, with proper sign, to the second angle, to get the required course.

The table for the 70th meridian is prepared as follows:

Local solar time on 70th meridian.	12 hrs.	0 mins.	0 secs.
Diff. time between 70th and 75th meridians	0 "	20 "	00 "
	11 hrs.	40 mins.	00 secs.

This last is a constant, to which is applied for each day the figures under the head of "Equation of Time" in the "American Ephemeris," published by the Government at Washington. These figures begin on page 400 of this year's issue, and are figured for Washington; but the change from the corresponding figures for Greenwich is so slight that the Washington figures are probably right within a second for any point in this country east of the Mississippi.

At the present writing, the sun is slow, and the correction is plus, but the sign changes back and forth with the season. On account of the sun's rapid motion and the difficulty of obtaining time to the last second, the error will rarely be less than half a minute of arc and may easily run to a minute or more. Even with this, the work will be nearly as good as by the ordinary pole-star observation, and, of course, much better than any compass reading.

In the months when the sun is low, an excellent substitute for the eye-piece attachment is a plain white card, which, after the eye-piece cap has been taken off, is held a few inches back of the eye-piece. The telescope is pointed at the sun by means of its shadow on the card, and when the card is held at the correct distance, and the cross-hairs are properly focussed, a sharp image of the sun and of the cross-hairs appears on it. By watching the movement of the black line across the sun's image, the contacts may be observed nearly or quite as well as with the attachment. But when the sun is high, the shadow of the lower plate cuts off this image, and the card cannot be used.

Has any reader of the News used these methods? If so, or if any one wishes to make any remarks on the theory of the thing, I should be very glad to know about it.

Yours, T. P. Perkins.

Chief Engineer's Office, Boston & Maine R. R., Boston, March 14, 1904.

Suggestions for Rebuilding Baltimore.

Sir: Having read with great interest the accounts of the Baltimore fire given in Engineering News of Feb. 18 and 25, I desire to advance a few suggestions which may be, I hope, of some account. I witnessed the great Chicago fire and did my share in rebuilding, but since then the art of building has made fair progress. Even I have reasons to pride myself in this regard with having made, in 1884, the first move toward concealed iron construction, which is at present so much in vogue. I hope that on this account I may be excused for advancing suggestions, the more so since I am of an age which puts me beyond the pale of business relations.

The photographs and accounts given in your paper seem to make it evident that more than one-half of the substance of the most preserved of the fireproof buildings, so-called, is gone, and that of the Equitable next to nothing is left beyond its foundations. And this is the outcome, although not any of these buildings had been used for mercantile purposes, had contained anything but mere office furniture! They were mainly destroyed, so far as they are, by the intensely heated atmosphere which was hurled over and through them.

That office buildings of the kind stand ordinary fires is a fact well established. But equally true is the contrary fact in regard to buildings filled with combustible merchandise, as once shown at Minneapolis and again at Pittsburg. Yet a fireproof building ever offers more or less resistance to a spread of fire, and should on this account be highly valued. The authorities at Baltimore would therefore show a gigantic spirit of courageous progress by deciding that every part of the burnt district shall be built up fireproof. This would stop all future wholesale business of the fire fiend beyond every doubt, and the sprinkler system would retrench his retailing.

Probably very little can be done in regard to fireproof tall buildings to ever get them to withstand a wholesale conflagration. Human pride will ever be inclined to uphold appearances. Plate glass and marble, granite and other costly stone will never be dispensed with. Mere constructional parts, on the other hand, may readily be made better adapted for withstanding fire. Thus iron piers may be made more massive and receive a compact solid envelope. The section here given (Fig. 1) shows a heavy 10-in. beam with two tees and four angles all ½-in. thick, is all sufficient for carrying twelve ordinary stories of a mere office building. The enveloping material is a mixture of mineral wool and plaster of Paris, tied with heavy asbestos thread and then finished with asbestos mortar to the proper thickness. Such a column in the lower stories of an office building should be 17 to 18 ins. in diameter, instead of nearly twice that which it generally is with the present methods, based on the idea that air, as the most positive nonconductor, must be kept surrounding the iron. This idea, however, ignores the plain fact that air is heated by contact. Thus the loose air surrounding the column becomes gradually heated, so much so, that by its expansion it blows off the entire envelope. Since this can occur only in cases where this envelope is positively airtight, it does so merely as an exception. Air, in order to act most efficiently as a nonconductor, must be confined within the minutest spaces, such as are offered by porous solids or by finely grained loose matter. It is time at last that an old superstition be abolished. Protecting envelopes for iron should by all means be made solid with every possible exclusion of loose air.

A manner of treating ceilings is shown by Fig. 2. The usual protection of beam-flanges is to be extra thick and made of a sort of fireclay. The arches are to be any sort of stiff concrete, the finish as usual, except in mercantile and storage buildings, which require asbestos plastering not less than ½-in. in thickness. These kinds of buildings should also receive a finished lining against all their bearing walls, which lining may consist of tiling, say 2 ins. thick, well secured, and covered with plastering.

Explosive liquids anywhere to be kept for use or sale should all be kept in tight tanks buried below the floor of cellar, ventilated through the roof and filled from without through pipes established for the purpose. There can be no difficulty in likewise establishing other pipes for purposes of using or retailing these liquids.

Mill constructed buildings, if permitted, should have floor construction of girders and floor plank merely, such plank to be of specified thicknesses—in no case less than 6 ins. thick—for different spans, and laid close together. No communication should be from floor to floor except through fireproofed doors.

Existing building laws are everywhere deficient and it is to be hoped that Baltimore may set a wholesome example in this line, though the case is exceedingly difficult. Lawyers are not posted on this subject-matter; architects and builders, on the other hand, not on the matter of generalization. Up to the present time they have manifoldly failed therein. Most of their laws are but specifications of a particular character. In no case do they exhaust the subject-matter which is on hand at the time, though even in fact it keeps growing from time to time. As matters are, the Building Commissioner is in the position of a judge who must ever add to or deduct from the specified code of law in accordance with his best judgment, which may or may not be a proper one. In order to overcome this dilemma, he should be made subject to a certain committee to whom he is to refer all doubtful cases for immediate decision, such being ever required in cases of building.

That there are cases in which, in spite of best intentions, building laws are made contrary to sound sense, was but recently shown in Chicago. In consequence of the late Iroquois horror it was undertaken to amend the very defective building laws in regard to theaters. The new law contains an order to the effect that every theater shall be surrounded by an open space on each of its four sides. This is for the purpose of affording additional emergency exits. But it seems to be very clear that a mere street front of such theater, large enough to allow side buildings therewith as part and parcel of the same, is by far the preferable for the purpose. Doors at each side of the house may then be had, to lead from all its parts into such side buildings, so that within the briefest span of time every member of a crowded audience could arrive, without the slightest possible discomfort, on a secure place. Yet such comfort in emergency cases is expressly forbidden by the new law!

Another serious fact is that the law orders stairs to be with landings. This is not merely a meddling with matters not concerning legislation; it is also strictly contrary to sound sense. Everybody knows that rapid descent on stairs is impeded by landings. I give these facts for the purpose of cautioning the Baltimore authorities against a hasty adoption of such Chicago rules.

Very truly yours, Frederick Baumann.

Chicago, Ill., Feb. 28, 1904.

A Detailed Criticism of the Specifications for a Sewer System at York, Pa.

Sir: It has been with interest and a desire to congratulate you that I have noticed the fair and impartial manner in which from time to time you have discussed in your issues various specifications, not only from the standpoint of municipalities and engineers, but also with a view of obtaining somewhat clearer specifications for the guidance of contractors who bid upon our public works. We are coming to understand that nothing is gained for the municipality by the Engineer "keeping facts up his sleeve," thereby leaving the contractor to bid in the dark or uncertainly, but that the cheapest and most economical construction is obtained by the fairest possible dealing, the most equitable methods and the frankest statement of facts; that the City does not in the end, often at the expense of a law suit, profit by seeming to get from contractors what it does not pay for, and that all contractors are not given to slighting their work, but rather desire to do good and thorough work, if reasonable prices and compensation can be assured. Therefore, it should be the aim of every engineer to seek with all earnestness that form of contract and specifications which shall secure the greatest fairness to both city and contractor, and this can only be done by placing unreservedly before the contractor all the conditions, carefully investigated and worked out, of the work which he is about to bid upon, and above all, leaving no uncertainty in his mind as to the treatment which he will receive regarding the unknown quantities which are unavoidable upon much of the public work before actual construction, and making provision for the payment of them in the contract and specifications. To do otherwise than this is to have the bids higher than need be the case.

It has been the encouragement of this spirit that has semed to animate your recent discussions along this line, and I, therefore, as a disinterested party, take the liberty of addressing you concerning a bidding which recently took place, the advertisement for which appeared in your paper, feeling that you will the more readily give the matter your attention, since the mouths of successful bidders must of necessity always be closed lest their criticism of specifications might affect their future welfare, and since the unsuccessful bidder feels a hesitancy perhaps induced by the old story of "The Fox and the Grapes," and so if the truth is ever to "out," it must be through such columns as yours.

On Feb. 23, the writer was called in by a large and well established contracting firm to assist them in the preparation of their bid for the sewers at York, Pa., and the plans and specifications, drawn and prepared by Messrs. Hering and Fuller, Chief Engineers of the work, were turned over to me, and their careful examination commenced upon the ground.

The contract itself states that it is founded on an appropriation duly made by the Councils of the City of York, under an ordinance entitled "An ordinance authorizing the making of a loan of $400,000 for the purpose of constructing a general house drainage sewerage system throughout the City of York, and providing and constructing a disposal plant in connection with said system of sewerage, and authorizing the issuing of bonds for the payment of said loan," approved the 18th day of August, 1903. The plans and specifications, however, contained no provision for "constructing a disposal plant," neither did they provide sewers on all streets in the city.

Turning to the specifications and plans, it is, to say the least, unfortunate that so many inexactitudes were indulged in by the engineers, so much indefiniteness and

wavering, so much that compelled "bidding in the dark," as all these things tend undeniably to the raising of the bids detrimental to the city, while "improper claims and law suits have occasionally had their origin in just such a lack of sufficiently clear and definite statements when taking the preparatory steps for executing an engineering work." We do not know whether this unfortunate lack of definite information was allowed to remain in the specifications on account of inability to secure more satisfactory information, or from the mistaken idea that such wideness and latitude of provision under the contract would induce some unguarded contractor to come within the estimated cost of the sewerage system. The engineers, it is said, had a force of men employed upon this work for one year, and it would seem could have secured information concerning the character of the material and work to be encountered, yet on a number of important items the Notice to Contractors states that the quantities are "not now even approximately known," but that they "will announce assumed quantities immediately before the opening and reading of the bids."

This was true of rock excavation, cast-iron pipe substituted for vitrified pipe or brick sewers, lumber for permanent foundations, lumber for sheathing left in place, timber for piles in place, and several other items. No borings were made for rock, quicksand, etc., in any part of town—at least none were shown the contractors. It was assumed by the contractors that when these quantities were announced they would be as nearly approximate as was within the knowledge of the engineers, or, at least, as it was possible for them with care and diligence to obtain. Such, however, was not the case with respect to the possibilities of rock excavation. From a former superintendent of the water company and gas company, who has acted in that capacity for the water company for a period of 20 years, and for the gas company for 35 years, but whose opinion was not asked by the sewer engineers, the writer was enabled to get, during the few days he was in York, the exact depth at which rock had been struck all over the town in the laying of water and gas pipes. With his assistance the writer prepared a map for the use of his clients showing that there would in all probability be 125,000 cu. yds. of rock to be removed, and perhaps more. Yet the figure given out by the engineers after the bids were in, was 31,000 cu. yds. of rock.

The specifications and contract compel the contractor to finish the work on the 1st day of January, 1906, under a penalty for delay of $150 per day ($50 on each of three sections), yet no extension of time is provided to cover the time that may be required to excavate the difference between 31,000 cu. yds. of rock and the 125,000 cu. yds. in sight, if the data secured in the laying of gas and water pipes is of any value; but an extension of time to cover this is a right which, under the contract, the contractor is debarred from claiming, or, in other words, the contractor must allow in his prices for a possible overtime payment of about $50,000 for extra rock encountered. Moreover, if the bids exceed the appropriation or the estimated cost by the engineers, on a basis of 31,000 cu. yds. of rock excavation, how will the engineers account if the quantities of rock excavated amount to anything like 125,000 cu. yds.?

Certain other unfortunate points of indefiniteness in the plans and specifications seemed also to leave an uncertain feeling in the minds of the contractors, which undoubtedly worked ill to the city by raising the bids. Most, if not all, of these defects could and should have been eradicated by the engineers. A recital of a few clauses of the contract will clearly set these forth.

First. Concerning materials, where surely no doubts or uncertainties should have been allowed:

Sewer pipe: "Sizes up to and including 15 ins. in diameter shall be furnished in 2 or 3-ft. lengths as may be directed" by the engineer. The difference in cost between 2 and 3-ft. lengths represents as much as $3,600 on the contract, but no provision is made for extra payment to meet such election on the part of the engineer.

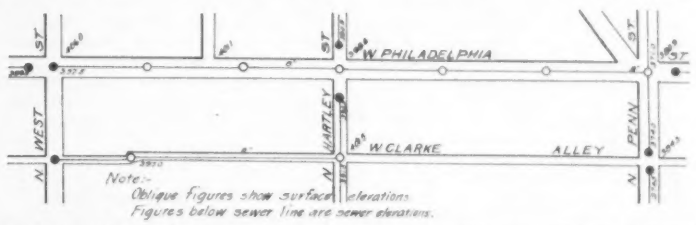
In the specifications for iron pipe for river crossings the engineers call for "bell-and-spigot pipe;" in a later paragraph they reserve the right to compel the contractor to use ball-joint pipe without extra compensation, the latter costing $4.50 per ft., as against $2.25 per ft. of the bell-and-spigot type. At least this is as near the price as a contractor can guess, for he must use pipe which will withstand a "pressure of 200 ft. of water." This is all the information given the contractor on the subject. How many engineers could figure the weight of pipe from this specification?

There is nothing in the specifications or on the plans to indicate to the bidder whether 5-in. or 6-in. flushtank syphons are required, although there are 228 of these specified, with a difference in cost to the contractor one over the other of 20%. Co-relative data on the plans would indicate the less expensive; the resident engineer advising bidding on the more expensive.

Second. Concerning excavation:

In over 35% of the trenches rock will be paid for at a width of 18 ins. at the horizontal axis of the pipe and below this one-half the area of a circle with a 9-in. radius. In 79% of the trenches rock will be paid for at a less width than 22 ins. at the horizontal axis of the sewer and below this one-half the area of a circle with a radius of 11 ins. The greater part of this rock is the hardest kind of blue limestone intermingled with quartz, with here and there throughout the town ledges of conglomerate. No attempt was made by the engineers to inform the contractors either of the distribution or of the location of these various kinds of rock over the town, no more than their quantities, and any practical man knows how impossible it is to blow out such material in such narrow trenches except at excessive cost.

The sewer was required to be bid upon at a fixed price for each size of sewer, excavated and laid to any depth, no indication being given by the engineers, as to the average depths of the cuts, either on the plans or in the specifications. The specifications state that profiles are filed with the board, yet for only 15% of the entire mileage of sewers advertised were there profiles, and these only on the larger and outlet sewers. There was not even a statement as to how deep the house laterals to the curb line were expected to be. For all the smaller sewers, surface elevations and elevations of sewers were given on the plans at most, but not all, of the street intersections, but no elevations or depths were indicated at any intermediate points. From such plans as these the contractors were obliged to guess for themselves the lengths of the various depths of cutting. In the absence of the proper profiles it was practically impossible for the contractor to determine beforehand the actual depth of construction, and it is well known that no intelligent bid can be prepared on small pipe sewer work by simply knowing the average depth of cut. To enable the contractor to make an intelligent bid the engineer must furnish a statement of the various amounts of the different depths of cutting with profiles showing the location thereof.



PLAN OF A PORTION OF THE PROJECTED YORK, PA., SEWER SYSTEM, SHOWING LACK OF ELEVATION DATA.

Other items, which should be looked for in the specifications, do not appear; for instance, although the plans show that some of the sewers are 30 ft. deep, still no provision is made for drop-manholes, deep-cut connections, or intersecting manholes. Neither does anything on the plans or in the specifications indicate the depths of flushtanks, the nearest surface elevation from which the depth might be secured being 100 ft. or more from the flushtanks marked on the plans.

The bids for sheathing and shoring were undoubtedly affected by the fact that the engineers reserved the right to order the contractor to cut off a portion of the top of the sheathing left in the trenches, compensation being made only for the lumber *actually left in place*, without any allowance whatever for waste, although this provision would render much of it entirely useless.

No uncertainty exists, however, in the contract and specifications as to the requirements laid upon the contractor, and his obligations thereunder, of which the following are a few: "The prices paid per running foot for sewer construction must include the removal of, and delay or damage caused by, any timber, masonry, or other structures or obstructions encountered in trench or tunnel (whether shown on the plans or not), except rock as hereinafter specified." The contractor shall maintain, and, if necessary, lay temporary water and gas and other pipe, and shall repair damage and keep them in repair for one year after the acceptance of the work in writing. Only permanent changes not indicated on the plans and specifications are to be paid for as extra work on the valuation of the engineer, and depending upon his decision as to whether the work done is or is not included in the work required of and bid for by the contractor under his contract. The contractor shall, if so required, connect, modify, or relay such portions of existing sewers in the city as may be utilized and incorporated into the new system at such points as directed, at the same price per foot as bid for new sewers. To relay old sewers and maintain the flow therein may prove a difficult operation. No mention is made of the extent of these, so an intelligent bidder must increase his bid to fully cover all contingencies in this particular.

Relative to such provisions, a few facts found upon the ground, but not indicated upon the plans, may be interesting. Information concerning the location of gas, water, steam, sanitary or storm sewer pipes already in existence, and the extent and location of the various kinds of pavement in the streets and alleys could have been readily secured, and with such requirements in the contract and specifications as to their care and maintenance, should have been. No plan, however, was presented to the bidders in this instance, nor was there any plan showing the old sewers which might be retained and incorporated into the new, nor was there a plan showing the pavements of the streets, although these comprised sheet asphalt, block asphalt, brick on concrete, brick on cinder foundation, Telford macadam, and macadam roadways, all of which are required to be replaced in as good condition as when found. Moreover, most of the alleys throughout the city have paved gutters, The gutters are in the middle of the alleyway and consist of a 12 or 15-in. brick pavement supported on either side by two or three feet of stone block or cobble pavement. At the solicitation of the writer, a day or two before the letting, an unofficial sketch plan of the pavements was prepared by the City Engineer, which was thereafter given to the contractors at so much a copy. It would have been a simple matter to have specified the number of miles or feet of each of the various kinds of pavement through which the contractor would be compelled to carry his sewer. Instead of this the contractors were given the idea that the pavements did not amount to much; that the concrete under the brick work was in rather poor condition, and that the city had not been keeping up its pavements on account of the possibility of sewer construction. But it was provided that 10% of the cost of the work be withheld, nevertheless, for one year, to guarantee the restoration of all streets and alley pavements. No pains should have been spared on the part of the engineers to give the contractors all the information possible to enable them to make intelligent bids. In the few days given him on the ground the writer discovered that in one alley about 12 ft. wide in which an 18-in. sewer was to be placed at a depth of 12 ft. or more, there already existed a 4-ft. brick sewer at a depth of 8 ft. No reference to this structure was to be found on any plan, nor were bidders apprised of its existence.

But sufficient facts have been given to show the paucity of information afforded contractors and the incompleteness and uncertainty of the plans and specifications.

A greater injustice, however, seems to be worked the contractors or the city perhaps in the end, from the fact that the plans of the system are so indefinite as to many details, so incomplete, that the contractor may be compelled to place the sewers at a depth of from 8 to 15 ft. without extra compensation, at the pleasure of the engineer, as illustrated in the accompanying plan.

By reference to it, it will be seen for example, that between N. West St. and N. Penn St., no elevations of the sewer are given. Is the sewer to be constructed on a uniform grade between these streets, or are there to be one or more breaks in the grade? On W. Clarke Alley, from the plan the depth of the sewer cannot even be surmised. This is not an isolated case of failure to give the elevations needed to determine depth of trenching.

Such an array of deficiencies allowed in the plans and specifications, for whatever purpose or reason, must ultimately affect any bidding, for contractors are bound as far as possible in the face of such possible odds to protect themselves, rather than give fair and reasonable prices upon their bids. Therefore it is not surprising that the lowest bids received upon this work, without a disposal plant, exceeded by $101,539.95 the appropriation made for the entire work, in which it was intended to include a disposal plant. And these bids, also, it must be remembered were based upon an estimate given by the engineers, of only 31,000 cu. yds. of rock excavation, which is clearly underestimated. The appropriation of $400,000 was intended no doubt to cover not only the bids of contractors upon the work, which now amount to $501,539.95, but also engineering and inspection, together with other probable contingencies, and cost of rights of way, none of which have as yet been secured.

No words other than the facts presented and the evidence of the bids received by the city are needed to point the moral of this tale, and it cannot but be seen that these criticisms are neither trifling nor technical, but vital.

Very truly, Alexander Potter.

143 Liberty St., New York City, Mar. 7, 1904.

(Proof of the above letter was submitted to Messrs. Hering & Fuller, and we append their reply as follows:

Sir: Criticisms are always welcome when they point out facts that have been overlooked or misrepresented. In the above letter, however, we fail to discover evidence that either of these failings exists. It gives evidence, on the contrary, that its author has misapprehended some of the main points which he raises.

(1) "Keeping facts up his sleeve." Funds were not available for borings all over the city and thus to ascertain the probable amounts of rock, piling and "sheeting to be left in place." No contractor wishing to make a fair bid in unit prices would be greatly disturbed by the absence of such borings although they are always a welcome addition to the surveys. In view of this absence,

the engineers suggested that fixed and fair prices be designated by the city for such classes of work, to avoid speculative and unbalanced bids. Local conditions, however, prevented this expedient. The best alternative was to withhold all estimated quantities for such doubtful work, on which the bids would have to be compared, until the time of opening them. In fact, they were not even definitely decided upon until just before that time. Under such conditions every careful contractor will make his own estimates of the probable quantities and place a fair price upon the unit of work, practically as though the price had been fixed for him by the city. Why should such a price have to be higher, when based upon the contractor's own best estimate of the probable amount of the special class of work, than if it were based upon the city's estimate, founded on no better information than that open to the conractors?

(2) Mr. Potter designates himself "as a disinterested party." Yet elsewhere he says that he had assisted in the preparation of a bid for a certain contractor, whose bid was among the highest on the list.

(3) His reference to the ordinance passed by Councils last August, authorizing a bond issue of $400,000 for constructing a general house drainage sewerage system throughout the city of York and providing and constructing a disposal plant, implies that this sum was fixed by the present Board of Public Works or its engineers. Such are not the facts. On the contrary, this sum seems to have been fixed upon somewhat arbitrarily in an ordinance passed by Councils Dec. 6, 1902, which provided for an election on Feb. 17, 1903, to obtain the assent of the electors to making this loan. The Board now carrying out this work was not created until Feb. 23, 1903. Neither the Board nor its engineers have considered the bond issue sufficient to do all the required work. It is believed, however, that with amendments to this ordinance the work can be properly carried out.

(4) In speaking of the specifications, we respectfully refute the imputation of having the object in view that "such wideness and latitude of provision under the contract would induce some unguarded contractor to come within the estimated cost."

(5) Mr. Potter asserts that the quantities given for rock excavation were not those which it was possible for the engineers "with care and diligence to obtain." He quotes information in possession of the water and gas companies which he considers to indicate that in all probability there would be 125,000 cu. yds. of rock, "and perhaps more." We also had this information before us, and in addition thereto even better evidence from numerous cellar excavations. The amount of rock excavation by which the bids were compared by us was 31,000 cu. yds. We have since been told by some local parties that even this figure was too high. A fair bid per cubic yard would not have injured any contractor, whether our figure or that of Mr. Potter is nearer the truth. Should the former be materially exceeded, the Board of Public Works, who fixed the time limit, would not ask impossibilities, and would no doubt grant a fair extension of time, provided, as specified in the contract, the claim for extension were certified to by the engineers as just and proper.

(6) Mr. Potter cites still other points which he says "undoubtedly worked ill to the city in raising the bids."

(a) Concerning 2 and 3-ft. lengths of small sewer pipe.—This choice is not unusual in specifications and is desirable. According to our experience and information there is as a general proposition no material difference in cost per foot as laid.

(b) Concerning the iron pipe for river crossings.—The 200-ft. head is specified to get pipe that will withstand the effects of time, not of pressure. It is not difficult to make a fair bid for this requirement. Ball joints are optional with the contractor.

(c) The size of the flushtank siphon.—The plans show the type of tank desired and the siphon outlet as being 6 ins. in diameter, which fixes the size of the siphon. No drawings of a particular siphon were shown because it was not desired to demand a definite patented article.

(d) Width of trenches in rock.—A definite and customary width is specified for the purpose of eliminating the necessity of measuring the same in the trench. Such a measurement cannot be accurately made, as every one knows. If the contractor is informed as to the exact width for which he will be paid, he can determine his price accordingly. If he thinks that he cannot remove the rock within the specified limits, he must accordingly add to his price per cubic yard, as he adds for extra depth, extra haul or for any special difficulties arising from the nature of the work.

(e) Profiles shown only for sewers of 15 ins. in diameter and over.—The smaller sewers are in general laid practically parallel with the street surfaces at a fixed depth below them. It is therefore of almost no value to the contractor to show a lot of parallel lines. The necessary street and sewer grades were marked on the plans practically without exception. The sewer grades were given at all manholes where changes of slope occur, and surface elevations at street intersections and at intermediate points where the surface slope was not substantially uniform. The depth of the house connections cannot be accurately known in advance, and will vary somewhat. For almost all of the sewers, as is well known, they will practically be as deep as the sewer pipe. Where in the case of mains the sewer pipe may here and there be of excessive depth, the houses are connected to a separate pipe sewer which enters the main at a manhole and is of course paid for separately at the price bid per lineal foot.

(f) Paying only for lumber actually left in place, without allowance for waste.—This provision is usual and proper. Cases are on record where, in the absence of this provision, large sums of money have been claimed for an unnecessary amount of lumber used in shoring which projected high above the street surface. The bid should cover the waste. If the contractor is not paid for it he will naturally reduce the waste to a minimum.

(g) Regarding pavements.—There are but a few blocks of first-class pavements in York, and these are right in the center of the city, which every bidder would naturally see. Most of the other streets are either macadamized or dirt roads. It was not thought necessary to have a special plan showing these facts.

(h) Concerning drop-manholes and deep cuts.—There are no 30-ft. cuts. Drop-manholes are provided where required, with grades properly shown on the plans.

(7) The figure shown by Mr. Potter is not a correct copy of the plan, one sewer with a controlling grade being omitted by him. One street elevation was accidentally omitted on the plan. Sewers are supposed to be straight between elevations marked on the plan, and therefore it is not necessary to mark them more frequently.

(8) While Mr. Potter's strictures emphasize the well known necessity of exercising the greatest care in drawing up plans and specifications, they evidently did not prevent some of the best contractors, with practical knowledge and experience, from presenting fair bids for the work.

Hering & Fuller.

Augusta, Me., March 22, 1904.

Notes and Queries.

Will "Engineer," of Harrisburg, Pa., please send us his name and address? We can not publish communications which come to us unaccompanied by the name and address of the writer.

NICARAGUA HAS LEASED HER RAILWAYS, says U. S. Consul Chester Donaldson, of Managua. On Jan. 1, 1904, the government turned over its national railways, repair shops, stations, rolling stock, etc., to Mr. Julio Wiest, a German citizen residing in Managua. The lease is to run for ten years with privilege of renewal. The lease provides that 10% of the gross income is to be devoted to repairs, improvements, etc., and 25% is to be turned over to the Nicaraguan government as rental; the remaining 65% is to cover expenses of operation, profits, etc. Mr. Wiest will have the preference on any new lines the government may desire to construct; but he is forbidden to transfer or sublet the road except to parties approved by the government, and on no conditions to transfer the property to any foreign government.

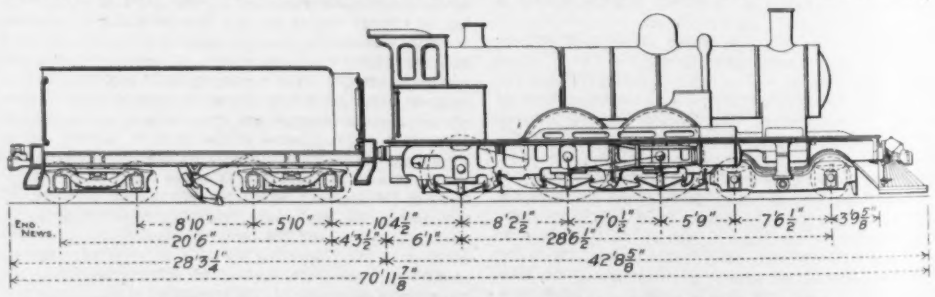
FRENCH LOCOMOTIVE FOR THE PENNSYLVANIA R. R.

The De Glehn four-cylinder balanced compound locomotives have made such remarkable records in France, particularly in maintaining continued high speed with heavy trains, that engines of this type are to be tried in England, on the Great Western Ry., and in this country, on the Pennsylvania R. R. Both of these engines were built by the Societe Alsacienne de Constructions Mecaniques, of Belfort, France, but each has had certain changes made to adapt it to the conditions of the road using it. Both are passenger engines of the Atlantic (4-4-2) type. The Pennsylvania R. R. engine is practically identical with those of the Paris & Orleans Ry., and practically the only changes are the addition of the pilot, bell and muffler pop safety valves, and shifting the engineman's accessories from the left-hand to the right-hand side of the engine. The accompanying cut is from a drawing, for which we are indebted to Mr. A. W. Gibbs, General Superintendent of Motive Power, Pennsylvania R. R.

It will be noted that the engine has two outside cylinders driving the rear coupled axle and two inside cylinders driving the front coupled axle. Each cylinder has its own valve and valve gear, so that the cut-off of the high and low pressure cylinders can be varied independently. It will also be noted that the driving and trailing wheels are considerably larger than is usual in this country. The tender is of French design and construction, and is fitted with a water scoop. The general dimensions of this engine are as follows:

Driving wheels (4)	6 ft. [illegible] ins.
Truck wheels (4)	3 " [illegible] "
Trailing wheels (2)	5 " [illegible] "
Wheelbase, driving	7 " [illegible] "
" truck	7 " [illegible] "
" total engine	28 " [illegible] "
" tender	20 " [illegible] "
" engine and tender	59 " [illegible] "
Truck pin to driving axle	13 " [illegible] "
Length of engine	42 " [illegible] "
Length of tender	28 " [illegible] "
Length over all*	70 " 11¾ "
Width of engine	9 " [illegible] "
Weight on driving wheels	87,000 lbs.
" on truck	44,000 "
" on trailing wheels	35,160 "
" engine in running order	166,000 "
" engine, empty	137,400 "
" water in boiler and fuel on grate	13,200 "
" tender, loaded	132,500 "
Cylinders, h. p. (2)	14[illegible] ins.
Cylinders, l. p. (2)	23[illegible] "
Boiler, straight top, diameter	4 ft. 11½ "
Working steam pressure	227½ lbs.
Tubes (Serve's ribbed), No. 139; inside diameter	2[illegible] ins.
Tubes length between tube plates	14 ft. 5¼ "
Heating surface, tubes	2,435.7 sq. ft.
" " firebox	181.1 "
" " total	2,616.8 "
Grate area	32.9 "
Capacity of tender tank	5,500 galls.
Capacity of coal space	22,000 lbs.

*Engine pilot to tender coupler.



FRENCH FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE FOR THE PENNSYLVANIA R. R.

Alfred De Glehn, Designer; A. W. Gibbs, General Superintendent of Motive Power, Pennsylvania R. R.; Societe Alsacienne de Constructions Mecaniques, Belfort, France, Builders.

LOW TON-MILE COST ON THE "BESSEMER" ROAD.*

While the operating expenses of railroads all over the country showed an increase in 1903, the Pittsburg, Bessemer & Lake Erie R. R. still kept well within the limits of the ton-mile cost set by its projector. The ton-mile cost in 1903 was 2.36 mills, against 2.22 mills in 1902 and 1.87 mills in 1901. The increase of 0.14 mill from 1902 to 1903 is more than explained by the increased cost of supplies. Thus, the average cost of coal in 1902 was $1.07 per ton and in 1903 it was $1.35. Wood increased from $1.25 to $1.35 per cord. The great difference between 1901 and the two following years in ton-mile cost is due in considerable part to a change in the system of accounting, by which all expenditures after 1901 are charged to maintenance. In that year a construction account was carried.

The "Bessemer" road has operated under a disadvantage, which was reduced in 1903. It started with comparatively little return haul to balance the ore, which constitutes the great bulk of the south-bound tonnage. In 1903 the north-bound tonnage was 2,046,071 tons, an increase of 458,138 tons, the coal tonnage being 1,427,635 and contributing 423,320 tons of the increase. The ore moved has been as follows:

1901	3,622,417 tons.
1902	4,685,045 tons.
1903	4,370,179 tons.

This ore goes to the Duquesne, Edgar Thomson and Carrie furnaces of the Carnegie Steel Co. It was expected that between 4,500,000 and 5,000,000 tons would be moved in 1903, but the sudden curtailment of blast furnace operations prevented the realization of this expectation. This ore is carried on a 20-year contract, at 3½ mills per ton per mile. With the north-bound freight tonnage 24% of the south-bound in 1901, 21% in 1902, and

*From "The Iron Trade Review."

20% in 1903, or 25% on an average, it is certainly doing the work cheaply to haul a ton of freight a mile for 2.15 mills as an average of the total tonnage either way in the three years.

CHIMNEYS FOR LOCOMOTIVE ROUNDHOUSES are being tried in Germany on roundhouses lying in closely-settled portions of cities. The object is to discharge the

Fig. 1. Four-Inch Theodolite as Used on U. S. Government Surveys.

(Circles read to 30″; three leveling screws.)
Geo. N. Saegmuller, Washington, D. C., Maker.

smoke at a higher elevation than do the individual smoke-jacks so generally used. The lateral ducts leading from the hoods to the stack are carried in the roof-trusses. They have generally been made of concrete-steel. Several roundhouses in Halle and Leipzig have been equipped in this fashion.

DESIRABLE FEATURES IN A TRANSIT FOR TOPOGRAPHICAL SURVEYS.

By Geo. Jacob Davis, Jr.*

The engineer's transit has reached its present stage of development after many years of experiment. Weak parts have been strengthened, accuracy increased and conveniences for operation provided which leave little to be desired when the instrument is used for ordinary work. The recent more general use of the stadia method of surveying has, however, made demands which the transit is hardly prepared to meet. It is thought that it may be profitable to review the requirements of a telemeter and of the various improvements introduced by some of the more progressive makers with a hope of aiding somewhat in the development of a standard form of stadia instrument.

The Hammer-Fennel tachymeter, described in Engineering News of Aug. 13, 1903, seems well adapted to the work for which it was designed, but, except in the rare instances where a specialty is being made of stadia work, the engineer will prefer a universal instrument having all the advantages of the modern transit and in addition such attachments or proportions as will render it available for use in rapidly and accurately measuring distances with the stadia.

In topographic surveys, horizontal distances determined to the nearest foot are amply precise, while differences of elevation are generally required to the nearest tenth, and a stadia circuit several miles in length is expected to close on the starting point with an error in elevation of only a few tenths. For this grade of work a vertical circle having at least the precision of the horizontal circle is required, yet on most instruments we find the poorest kind of a device for determining vertical angles. The verniers, usually a single one, are rigidly attached to the standard, so that when an adjustment of the horizontal axis is made the circle is likely to be thrown out of the

*Civil Engineer, Room 20 Grant Building, Atlanta, Ga.

plane of the vernier, introducing parallactic errors into the readings. It would seem desirable to have the verniers attached to a plate or frame having a long cone bearing on the horizontal axis similar to the vertical centers. This arrangement, when once carefully adjusted by the maker, would retain the circle and verniers in the same plane and would allow of more careful fitting of the parts together. A level-vial of a sensitiveness equal to that attached to the telescope should be provided on the vernier plate of the vertical circle and a slow motion screw for controlling the position of the verniers is also essential to accurate work. The vertical circle should be just as thoroughly protected as is the horizontal circle by a water and dust proof cover having glass windows over the verniers and level-vial, which also should preferably be inclosed. To render possible the discovery and elimination of eccentricity there should be two verniers provided and placed 180° apart. A vertical circle and vernier divided to read to 30″ is recommended. With this the reading should never be more than 15″ in error, if the instrument is in adjustment, which would make an error in elevation of less than a tenth in a 1,000-ft. sight.

The graduation of large and small instruments is generally performed on the same graduating engine, hence they should have the same degree of accuracy of graduation. A given amount of eccentricity would, however, introduce a larger angular error into the reading of a small than on a large circle, but with the careful centering now possible in the shops of the best makers no trouble is to be experienced on this account in a high grade instrument. An instrument with small circles has greater rigidity, especially if the compass box is retained, necessitating the attachment of the standards to the thin plate at some distance from the axis. The size of circles to be chosen would seem, then, to depend principally on the ability or ease of reading the graduations. A 30″ silver graduation on a 4½-in. circle can ordinarily be read without a magnifier. Five

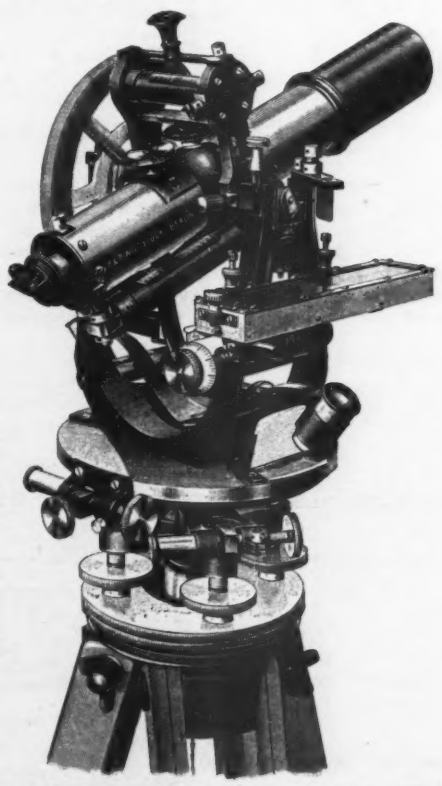


Fig. 2. Transit-Theodolite with 4-in. Circles Reading to 20 Ins. and Detachable Oblong Compass Box at Side.

(Weight of complete instrument, 7 lbs. Magnifying power of eye pieces, 18 and 22 diameters.)
P. & R. Wittstock, Berlin, Germany, Makers.

or five and a half inches without magnifiers and four and a half or four with permanently attached compound magnifiers would be convenient sizes. The graduations should always be on solid silver with a dull or frosted finish.

The bubbles on the telescope and on the vertical vernier frame should have a sensitiveness of 20″ per division of one-tenth-inch. These would enable an accurate adjustment of the zeros of the verniers to correspond to a horizontal line of sight and would also make the instrument a reliable one for leveling. The graduations should be

Fig. 3. Transit with Vertical Circle Completely Enclosed.

(Weight of complete instrument, 4¾ lbs. Magnifying power of eye-pieces, 12 and 16 diameters. Circles 3¼ ins. in diameter.
P. & R. Wittstock, Berlin, Germany, Makers.

marked on the glass of the tube instead of on a metal scale suspended some distance above. The plate levels should both be of the same sensitiveness, of about 1′ per tenth of an inch division.

In determining the proper power for the telescope, the old rule has been to adopt such a power that the slightest movement of the vernier or bubbles will cause an easily observed movement of the field of view. This is not sufficient in the telemeter, for though in a long sight the observer may be able to bisect the rod very accurately with such a telescope, he may not be able to read the graduations on the rod at all, and though a lateral movement of a fraction of an inch may be plainly discernible, a movement toward or from the instrument of several feet may not be noticeable.

In the last few years the makers have been increasing somewhat the power of their telescopes to meet the demand of the topographer. There are many difficulties to be overcome in increasing the power of the telescope and it may readily be increased to such a degree as to seriously impair the usefulness of the instrument. High magnifying power is obtained only by a loss in the size and brightness of the field. To regain the loss of light the diameter of the objective must be increased, requiring a lengthening of the telescope, which adds to the weight and bulkiness of the instrument and the area which it presents to the wind. The length should be kept down so that the telescope may be transited over at least one end without increasing the height of the standards to an objectionable extent.

The proper focal length of a lens varies as the first power of the diameter while the brightness of the image varies as the square of the diameter. A slight increase in the length of the tube may, therefore, result in a very considerable increase in the illumination. Should the focal length be too short the illumination will be good but the definition will be poor and vice versa; hence proper proportions must be maintained in order to secure both good definition and good illumination. By the introduction of the improved Jena glass it has been made possible to construct telescopes

of shorter focal length than formerly, retaining high power and good illumination.

Telescopes of 11-in. focal length and 1⅜-in. aperture of objective, having a power of 30 diameters, can now be obtained from reliable manufacturers. A telescope having a power of 30 diameters would, under good conditions, render divisions 1-100 of a foot in width just discernible at a distance of 1,000 ft. With such a power and a suitably graduated rod the error of reading distances can readily ke kept within the limits ordinarily set for farm surveys made by chaining. In hazy weather or in early morning or late evening work on winter days this power may prove too great, owing to insufficient illumination. This difficulty can be overcome by providing an extra eyepiece, at an additional cost of about five dollars, having a power of about 20 diameters. Assuming the same transparency of the lenses and a diameter of pupil of the eye of 0.09-in., the brightness, or light per unit of area for the power of 20 diameters as compared with the power of 30 diameters will be as 36 is to 16. An additional advantage of the lower power lies in the greater ease of finding a point, owing to the enlarged field and the much greater ease in focusing. High powers require very exact focusing to prevent sensible errors due to parallax. Where a large number of short sights are to be made the lower power has decided advantages, and the possession of two eyepieces would greatly enhance the serviceability of the instrument. Telescopes intended for stadia work should invariably be inverting, as the additional lenses required in the erecting eyepiece obstruct an appreciable quantity of light and unnecessarily lengthen the tube.

The diameter of the cross hairs placed in some instruments is entirely too great. They should be just large enough to be plainly seen when the low power eyepiece is being used. Any larger diameter reduces the accuracy of the reading. A wire having a diameter of 0.00025-in., which is the size used in one of the best makes, will cover 0.02-ft. on a rod at 1,000 ft.

The telescope should be balanced and provided with an adjustable friction on the bearings so that it will remain in any position desired without being clamped.

There seems to be a decided tendency to reduce the weight of the instrument as much as possible without decreasing the strength or rigidity, notwithstanding the objection on the part of some that additional weight adds to the steadiness. It would seem that any weight above that required for strength and rigidity would better be placed low down on the tripod legs, as in the rock drill, if it is applied solely for its steadying effect.

By dispensing with the large compass box and substituting curved standards, cast in a single piece with the center, a much more rigid design is secured and the standards can be made lower. A rectangular compass box, placed outside of the standards, containing a long, delicate needle will serve to place the line of sight in the meridian, when any bearing can be turned off by the horizontal plate.

The views on the preceding page show some of the latest designs for stadia instruments.

NOTE ON THE COST AND SPEED OF SINKING THE EAST SHAFT OF THE NEW KLEINFONTEIN CO. BENONI, SOUTH AFRICA.*

By Edward J. Way,† M. Am. Inst. Min. E.

The cost and the speed of sinking a shaft are factors of so great importance in operating a mine, that the data given in the table herewith will be of interest and value to all engaged in practical mining; and for this reason the data are communicated for permanent and accessible record in our Transactions.

The figures of cost cover the period, from Jan. 1, 1903, to May 31, 1903, during which time the total depth sunk was 858 ft.

So far as I know, the cost of sinking per ft. (£13 15s. 11.04d) of a shaft, of the dimensions 21 ft. by 6 ft. in hard rock, is the cheapest yet on record; and the speed of 213.5 ft. per month, which was attained during May, 1903, is also the best record for speed in sinking in rock so hard as that of this shaft. During the period from Jan. 1 to May 31, 1903, there were 144 rounds worked, involving 4,032 holes, of a total depth of 28,963 ft. 2.4 ins., which is equivalent to an average depth of 7 ft. 2.2 ins. per hole bored. These data are of added interest from the fact that the work was done practically by native labor.

Cost of Sinking East Shaft, from Jan. 1 to May 31, 1903.

		Cost		
		Total	Per foot sunk.	
Labor, etc.		£. s. d.	£. s. d.	
White wages		3,292 16 0	3 16 9	
Salaries		276 8 5	6 5	
Native wages		1,190 4 8	1 7 9	
Compound		616 11 3	14 5	
Workshops		108 13 2	2 6½	
Steaming station		1,353 3 3	1 11 6	
Rock drills		2,620 0 2	3 1 1	
Surveying		40 10 11	11¾	
Transport		13 10 0	3¾	
Traveling expenses		3 0 0	1	
	Stores.			
	Value			
Description. Quantity.	£. s. d.			
Candles ... 207.2 boxes.	135 3 4		3 1	
Detonators. 86 "	16 15 4		4¾	
Fuse ..... 2,475 coils..	42 3 6		1	
Gelatine .. 418 cases.	1,463 0 0		1 14 1½	
Iron bars,&c 696 lbs....	7 0 8		2	
Steel bars.. 2,528 "	45 1 9		1 0¾	
Rails .....65,445 "	325 6 0		7 6½	
Sleepers .. 250.....	18 1 7		5	
Bolts-nuts.. 1,263.....	18 6 0		5	
Dog spikes. 363.....	7 2 4		2	
Fish plates 3,011.....	35 19 4		10¾	
Asrtd nails 432 lbs....	4 15 10		1½	
Coachscr'ws 82.....	1 6 8		0½	
Oils, grease	7 2 4		2	
Piping .... 270 ft....	21 7 6		6	
Tools	11 6 8		5¼	
Timbr,asrtd 1,404 cu. ft.	71 16 0		1 8	
Sundries	89 5 9	2,321 0 7	2 1	
Total		£11,836 19 5	£13 15 11	

SEWAGE PUMPING PLANT FOR THE JACKSON PARK AVE. SEWAGE DISTRICT AT CHICAGO.

The intercepting sewer system at Chicago, which was described in our issue of May 28, 1903, will serve the South Side district as far as 73d St., but south of that street is a low-lying district extending to 87th St. which will be served by an independent sewer system, the sewage of which will be pumped to the head of the intercepting sewer on Jackson Park Ave. This system, known as the Jackson Park Ave. sewerage system, will drain an area of about 6,200 acres, lying between 73d and 87th Sts., Ashland Ave. and Lake Michigan. The larger portion of this area is flat low-lying land, having an elevation of about 6 ft. above the lake level, although the western portion rises to an elevation of 23 ft. The pumping station will be on the east side of Jackson Ave., adjacent to the south side of the Baltimore & Ohio R. R. The elevation of the bottom of the main sewer at the pumping station will be 17 ft. below datum, while the elevation of the bottom of the intercepting sewer at that point is 9 ft. below datum, making a lift of 8 ft. for the pumps.

The construction of this sewerage system is under the supervision of the Board of Local Improvements, which Board has charge of all work paid for by special assessment. The Board of Local Improvements has its own Chief Engineer, Mr. C. D. Hill, M. Wes. Soc. C. E., to whom we are indebted for much information contained in this article. The estimated cost of the entire system is as follows:

77,000 ft. of brick sewer, from 2½ ft. diameter, at $4 per ft., to 11 ft. diameter, at $25 per ft.	$117,365
461 manholes at $25.00 each	11,525
608 catchbasins and connections, $35 each	21,280
12,000 cu. yds. of rock excavation, $2 a yd.	24,000
Pumping station, including foundations, buildings, machinery and all appurtenances	112,830
Total	$887,000

The pumping plant will consist of four engines, each driving the horizontal crank of a vertical shaft 23½ ft. long, whose lower end is connected to a horizontal centrifugal pump. The two smaller engines will be duplicates of two engines now in use at the sewage pumping station at 73d St. and Railroad Ave., and it is expected that they will take care of the ordinary dry weather flow, which will probably be between 20 and 50 cu. ft. per second. The two larger engines will each have a capacity of 125 cu. ft. per second at an economical speed, and can be readily forced to a capacity of 175 cu. ft. per second. This will make a total capacity for the station of 400 cu. ft. per second when all engines are run at full speed. These pumping engines were designed by Mr. E. T. Adams, of Milwaukee, Wis., and the general design of the existing sewage pumping engines at 73d St. and Railroad Ave. was followed, as these engines have given very good satisfaction. This is sometimes known as the Boston type of the Allis-Chalmers engines. The contractor for this machinery will be required to install engines that substantially comply with the terms of the ordinance, which describes the engines in detail, although minor details can readily be made in conformance to the shop practice of the contractor.

While these designs follow the lines of the design of engines built by the Allis-Chalmers Co., the engineers have endeavored to make the designs sufficiently broad that any manufacturer of engines can readily produce them. All of this machinery will be paid for by a special assessment levied on the property benefited, and under the laws of Illinois it will be impossible to accept bids on competitive designs, for which reason the ordinance contains full and detailed specifications. It would be impossible to confirm the assessment, unless the ordinance was specific in all its terms. At the same time, with this limitation, the engineers have attempted to secure the utmost competition possible.

The two smaller engines will be of the Corliss triple-expansion type. Engine No. 1 will be of 100 HP., and will have cylinders 8, 13 and 18 ins. diameter, with a stroke of 24 ins.; it will drive

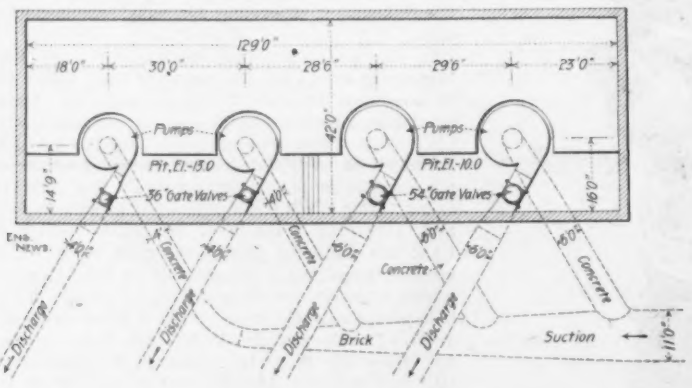


FIG. 1. PLAN OF SEWAGE PUMPS AND CONNECTIONS AT JACKSON PARK AVE. PUMPING STATION, CHICAGO.

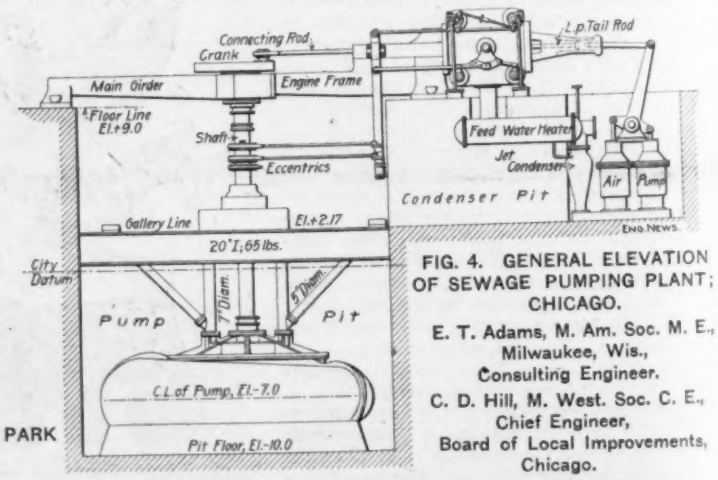


FIG. 4. GENERAL ELEVATION OF SEWAGE PUMPING PLANT; CHICAGO.

E. T. Adams, M. Am. Soc. M. E., Milwaukee, Wis., Consulting Engineer.

C. D. Hill, M. West. Soc. C. E., Chief Engineer, Board of Local Improvements, Chicago.

*A paper read at the Atlantic City meeting of the American Institute of Mining Engineers.

†General Manager Kleinfontein Group Central Administration, Benoni, Transvaal, South Africa.

a pump runner of the enclosed vane type, 7 ft. 6 ins. diameter, and weighing 7,000 lbs.; the suction inlet will be 42 ins. diameter and 24 ins. long, while the discharge pipe will be 26 ins. diameter at the pump casing and 48 ins. at its outer end. Engine No. 2 will be of 175 HP. and will have cylinders 9¼, 16½ and 23 ins. diameter, with a stroke of 30 ins.; it will drive a pump runner of

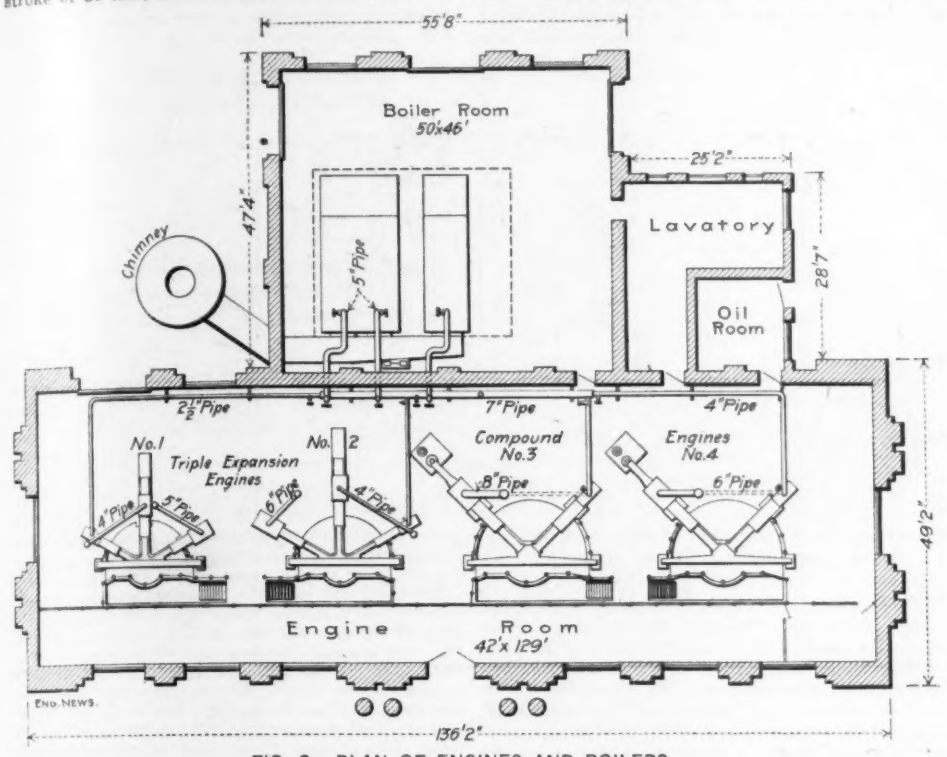


FIG. 2. PLAN OF ENGINES AND BOILERS.

the same type and size as the other but weighing 8,000 lbs.; the inlet will also be the same size as for No. 1, but the discharge will be 36 to 48 ins. diameter. These two engines will have receivers of the style shown in Fig. 11, connected to the cylinders by cast-iron pipes. In the discharge pipe of each pump will be a 36-in. double gate valve, designed for a pressure of 20 lbs., and operated by a 12-in. hydraulic cylinder supplied with city water at 25 lbs. pressure.

Engines No. 3 and No. 4 will be of 250 HP. each, and will be of the Corliss cross-compound condensing type, with cylinders 14 and 28 ins. diameter, 30-in. stroke; each will drive a cast-iron pump runner of the enclosed vane type, 7 ft. 6 ins. diameter. The suction inlet of each pump will be 4 ft. 3 ins. diameter, and the discharge pipe will taper from 4 ft. 6 ins. at the casing to 6 ft. at the outer end. In the discharge pipe of each engine will be a 54-in. double gate valve, designed to withstand a working pressure of 20 lbs., and operated by a 16-in. hydraulic cylinder supplied with city water at 25 lbs. pressure.

Fig. 1 is a plan showing the position of the pumps, with their inlet and discharge pipes. The floor of the pump pit is 10 ft. below datum for the two large pumps and 13 ft. below datum for the smaller pumps. Fig. 2 is a plan of the main floor of the pumping station, showing the positions of the engine cylinders, the boilers and main piping, etc.

DETAILS OF ENGINES NO. 3 AND NO. 4.

These cross-compound engines have their cylinders placed at right angles to each other, as shown in Fig. 3, while Fig. 4 shows the general arrangement of the engine, pump, valve gear and auxiliaries. The frames or bed plates, Fig. 5, have the cylinder end resting on the side of the pump pit, while the outer ends are carried by a heavy cast-iron girder, 20 ft. 10 ins. long, which spans the pit. This girder is of box section, 17 × 17 ins. at the center and 12 × 12 ins. at the ends, with metal 1¼ ins. thick. At the center of the girder is an enlarged portion to carry the main bearing and the quarter boxes, with faced pads to receive the ends of the two frames or beds carrying the slides of the two cylinders. The frame and slide for each cylinder are formed in a single casting, the frame being of box section 14 × 14 ins. where it joins the girder and 16 × 16 ins. at the end of the slide. The slide of the crosshead is semicircular, bored out to a diameter of 19 ins., and having three wearing surfaces. The cylinders are to be clothed with 2½ ins. of magnesia, containing 85% of carbonate of magnesia, covered with duck and given three coats of paint. They will then be lagged with No. 14 planished steel. Fig. 6 gives the details of the high-pressure cylinder with its valve chambers, etc.

The pistons will be of cast-iron, with bull-rings, packing rings and followers, and designed for pressures of 150 lbs. and 75 lbs. per sq. in. in the high and low pressure cylinders respectively. The piston rods will be of open-hearth steel, 2-13-16 ins. diameter. They will be fitted with metallic packing, steam tight under 150 lbs. pressure in the high-pressure cylinder, and air tight under a vacuum of 28 ins. of mercury in the low-pressure cylinder. The low-pressure cylinder has also a 2⅞-in. tail rod, from which the air pump is operated. The cast-iron crossheads will have removable and adjustable shoes, faced with babbit metal, and turned to fit the bored slides. This babbit is to contain 88% of tin, 4% of copper, and 8% of antimony. The crosshead pin will be of open-hearth steel with a bearing 4 × 4 ins., and the connecting rods, Fig. 7, will also be of open-hearth steel, 8 ft. 4 ins. c. to c. of bearings. The cast-iron crank will have a single crank pin of cast-steel, taking the two connecting rods, one above the other. The pin will have an upper bearing 5 ins. diameter and 3½ ins. long, while the lower bearing will be 6 × 3½ ins.

The shaft will be of steel, 9 ins. diameter and 19 ft. 3 ins. long, with its lower end rigidly attached to the pump runner, and fitted with a guide bearing, while its upper end is fitted to a bearing 9¾ × 17 ins. The thrust bearing, Fig. 8, will consist of alternate steel and bronze plates ground to a true surface and running in an oil bath. The thrust will be transmitted from the shaft by a cast-iron thrust nut clamped to the shaft, and will be received by a bearing plate resting in a spherical seat. The thrust transmitted to the bearing will be carried by a truss consisting of two 20-in. I-beams set in the masonry of the pit, the truss being completed by four cast-iron columns rigidly attached to the pump casing and to the I-beams, as shown in Fig 4.

The pump casing will be of cast-iron, bored out to 7 ft. 6¼ ins. diameter in the center, and having a suction inlet of 4 ft. 3 ins. diameter and a discharge nozzle 4 ft. 6 ins. diameter. This casing, Fig. 9, carries the lower guide bearing of the shaft, 9¾ × 24 ins. This will consist of strips of lignum-vitae dovetailed into a brass ring fitted into the bored recess of the casing, as shown. The pump runner, Fig. 10, will be of cast-iron, with enclosed vanes and a diameter of 7 ft. 6 ins.

Each cylinder will have two admission and two exhaust valves, those of the high-pressure cylinder being 4 ins. diameter, and those of the low-pressure cylinder 6 ins. diameter. A centrifugal regulator will control the point of cut-off in both cylinders. The valve gear will be of the Corliss type with a drop cut-off under the control of the regulator. It will have three eccentrics, one to operate the steam valves of both cylinders, while each cylinder has its exhaust valves operated by its own eccentric.

The receiver will be of the same type as used for all the engines, Fig. 11 representing the first

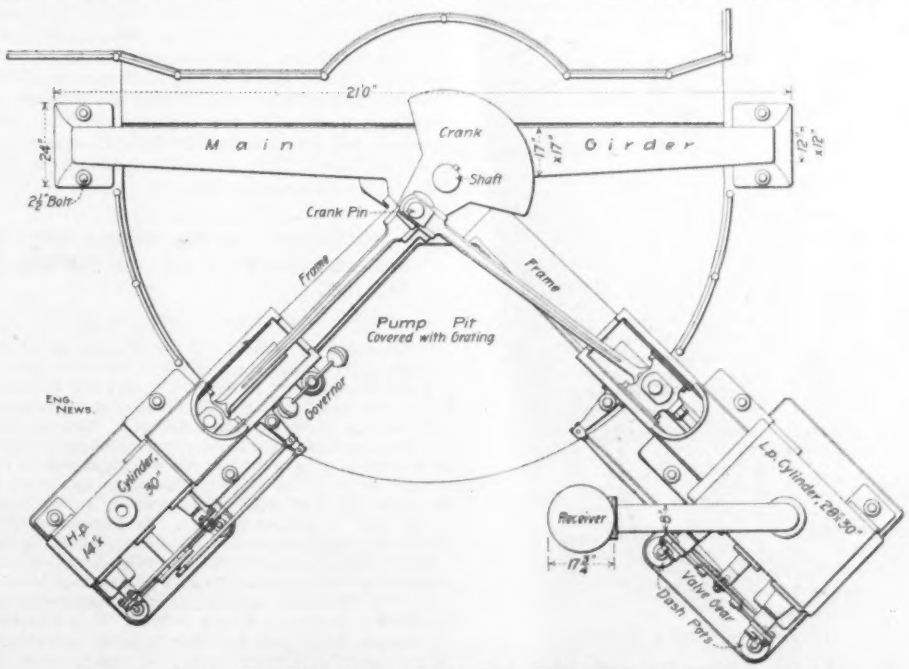


FIG. 3. PLAN OF COMPOUND CONDENSING ENGINE FOR SEWAGE PUMP.

receiver of triple-expansion engine No. 2. For the cross compound engines it will be 16 ins. diameter and 10 ft. 3 ins. high, containing a reheating coil of 170 ft. of copper pipe, 1 in. outside diameter and 1-16-in. thick. The exhaust feedwater heater will be in the exhaust pipe between the low-pressure cylinder and the condenser. It

will have a 16-in. cast-iron shell 6 ft. long, containing a coil of 180 ft. of copper pipe 1¼ ins. inside diameter and ⅛-in. thick. The condenser will be of the jet type, with a 10-in. steam connection and a 4-in. injection pipe connected with the main discharge pipe between the sewage pump and the valve. In addition to the exhaust pipe to the condenser there will be a 10-in. free exhaust pipe, fitted with an automatic relief valve, and having a 14-in. riser extending above the roof.

strength. The working pressure is to be 150 lbs. Each boiler will be supported by a steel frame, independent of the brick setting. The furnaces will be of the oven type, with cast-iron grates and fire-brick arch, and each furnace will have a grate area of 19 sq. ft.

PUMPING STATION.

The pumping station will have an engine room 42 × 129 ft., and a boiler room 50 × 46 ft.; there will also be a lavatory, oil room, etc. All the

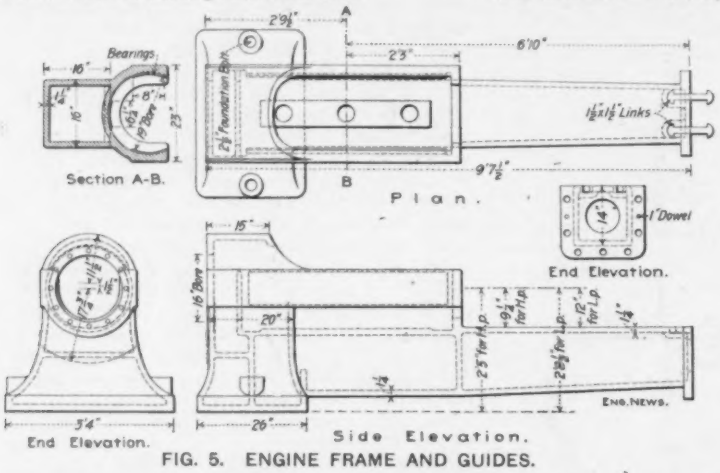


FIG. 5. ENGINE FRAME AND GUIDES.

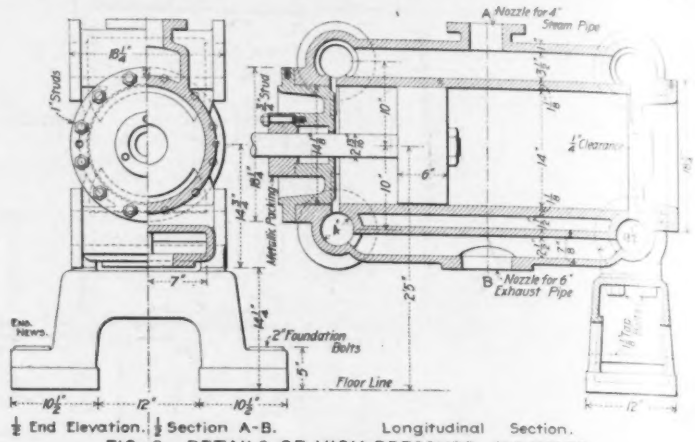


FIG. 6. DETAILS OF HIGH PRESSURE CYLINDER.

There will be a double cylinder single-acting air pump, operated by a bell-crank driven from an extension of the low-pressure piston rod, as shown in Fig. 4. This pump will have brass-lined cylinders 14 ins. diameter and 8 ins. stroke, and the pistons and delivery plates will also be of brass. The boiler feed pump will be operated by a link from the bell-crank above mentioned, and will have a single-acting brass plunger, 2¾ ins

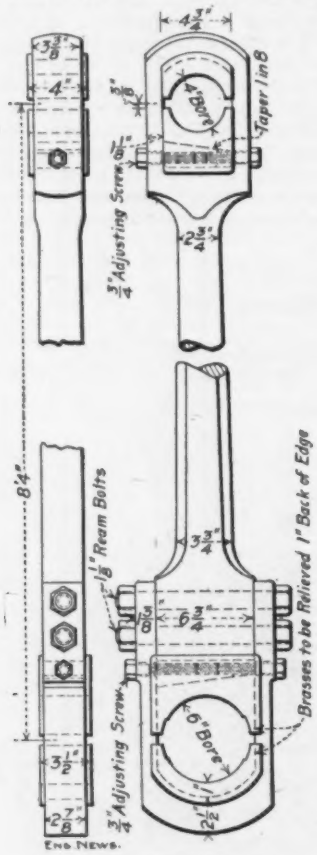


Fig. 7. Connecting Rod.

diameter and 5 ins. stroke. The suction pipe will be connected to the exhaust feed-water heater.

BOILERS.

Steam will be furnished by three water-tube boilers of 100 HP. (rated), of the type shown in Fig. 12, and having 1,000 sq. ft. of direct heating surface. The tubes will be of charcoal iron, lap welded. The drums and headers (or water legs) will be of open-hearth steel of 60,000 lbs. tensile

foundations for the building, engines, boilers, etc., and all the pump pits, suction and discharge conduits, etc., will be of concrete, composed of 1 part Portland cement, 3 parts sand and 6 parts of crushed limestone. The building will be of brick, faced with sand-mold brick and stone, while the interior of the engine room and lavatory will be faced with white enameled brick. The stone work will be blue Bedford limestone. The roof will consist of steel trusses connected by I-beam purlins, on which will be T-bars supporting the roof covering of 3-in. porous book tile, laid in lime mortar. Over the tile will be a layer of asphalted paper, and over this again, the slate covering. The sheet metal work will be of copper. The engine room floor will be of concrete, covered with sawed white oak matched flooring ⅞ × 2¼ ins., nailed to sleepers embedded in the concrete. The coal bunker will be of timber, with a capacity of 50 tons, and a track of 24 ins. gage will be laid from the bunker into the boiler room. The track will be laid with 16-lb. rails spiked to oak ties 4 × 4 ins., 3 ft. long, bedded in crushed stone level with the tops of the ties, except that in the boiler room they will be covered with the concrete of the floor, flush with the top of the rails. The chimney will be of radial brick, with stone cap; it will be 150 ft. high above the foundations, and 5 ft. inside diameter at the top.

THE APPRAISEMENT OF THE PHYSICAL VALUE OF WISCONSIN RAILWAYS FOR THE PURPOSE OF TAXATION.

By W. D. Taylor,† M. Am. Soc. C. E.

The so-called ad valorem bill for the taxation of the railways of Wisconsin passed both branches of the legislature and became a law in May, 1903. The law as passed plainly indicates that in the appraisement of the railways their earning power is to be considered. That is, their franchise value, or what is sometimes called their intangible value, is to have considerable weight, as well as the physical value of the property, in determining what is the actual value of each railway property in the state. By the terms of the law the State Tax Commission, consisting of three members and a secretary, constitute the State Board of Assessment, to which is assigned the work of assessing the railways of the state at their true value.

As a first step it was necessary to get an appraisement of the physical properties of each railway. It is held that the physical property of a railway is worth, not what it did cost, nor what it would sell for, but what it would cost to reproduce to-day in its present condition.

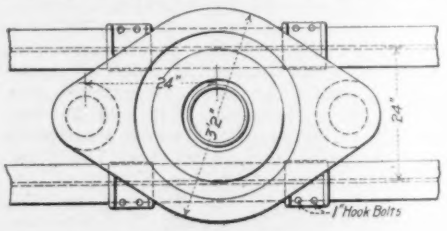
The work of finding the value of all the physical property of even one large railway system is in itself a large undertaking. Besides many other roads there are two large systems operating in the state which have about

*Slightly condensed from a paper in "The Wisconsin Engineer," for December, 1903; with additional matter supplied by Prof. Taylor at our request.

†Professor of Railway Engineering at the University of Wisconsin, Madison, Wis.

1,700 miles of line within the state and 7,000 miles or more in their whole system. Each of these systems has more than 1,000 locomotives and more than 40,000 freight cars employed in its business. The systems have been put together by the purchase of one short railway after another. When another line was bought and added to the system, it was sometimes the case that the construction records had been lost or burned, so that the new owners would know perhaps how many miles of main track and siding they were adding to their system; they would know, perhaps, what was the general condition of the new roadbed; they might take pains to learn how many cars and locomotives they were adding to their own list, and how many bridges of given span and material were included in the new track. But it did not matter with them whether the road was built on a 40-ft. embankment, tunneled through solid rock, or had the ties laid flat on the natural earth. To them there were so many miles of track in good or bad condition which could be made to earn so many dollars per mile. So it was small concern to them if they did not know how many cubic yards of grading, or how many acres of right-of-way, or how many yards of masonry, or pounds of bridge steel had been used in the making of the roadbed. Thus it happens that the information needed for fixing the physical value of a large part of the railways in the state is not in the possession of the officers of the roads as it is not in existence.

There is the matter of the right-of-way lands of the railways for main tracks, yards, shops, and terminals. Is the right-of-way, owned in long strips, any more valuable than the contiguous lands? It certainly is, because



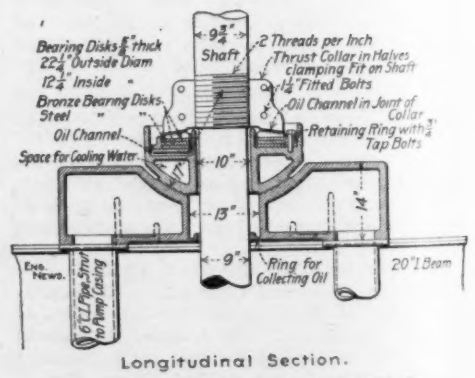


Fig. 8. Thrust Bearing of Vertical Shaft.

as a rule it cuts contiguous property in twain and does damage in the way of drainage and inconvenience to adjoining property. But how much more valuable is it? When the road was built the right-of-way may have been donated to encourage the construction of the road. The contiguous land may now be worth $60 or $5,000 an acre. Is this right of way which may have been donated now worth $60 or $180; $5,000 or $10,000 an acre?

Questions like these arise in regard to the value of almost every considerable item of property on a railway. It

would seem at first glance that the value of steel rail in the track of a railway should be about as simple a matter as could well arise in such an appraisement. The market value of the new rail and of scrap rail is quoted each week in reliable trade journals, and the length of each different weight of rail in the track is on record in most railway offices. But what is the value of rail in the track that has seen service enough to produce 60% of the total possible reduction from new rail to scrap? Suppose the price per ton at the mills in Chicago is quoted as $28 and $14, respectively, for new rail and scrap steel. One would hold at once that the wearing value was $14, and since 60% of that was gone, $5.60 of its wearing value still

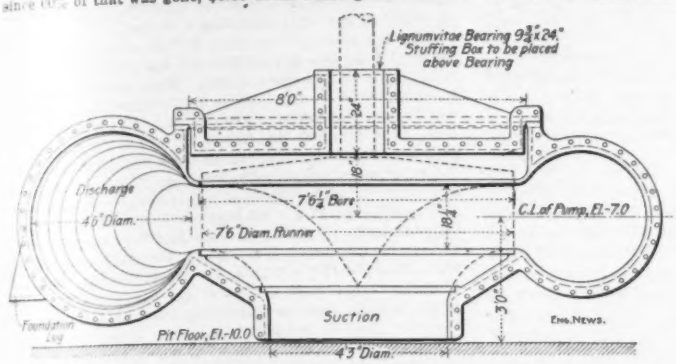


FIG. 9. CENTRIFUGAL SEWAGE PUMP.

remained, and the total present value, therefore, would be $5.60 + $14, or $19.60 per ton. But though this may be a correct solution there are some conditions connected with the matter that tend to make one doubt its correctness in all cases.

If the rail is used at a point 200 miles from Chicago it will cost $1 per ton to transport it to the point where it is used. It will cost $2.50 a ton to lay it, line it, and surface it. Thus by the time it is laid as new steel ready for use it has cost $31.50 a ton. Now if it remains in the track until reduced to scrap the market scrap value is not available till $1 per ton is spent on it in removing it from the track and loading it on cars, and $1 more per ton in transporting it back to the mills. In the mean

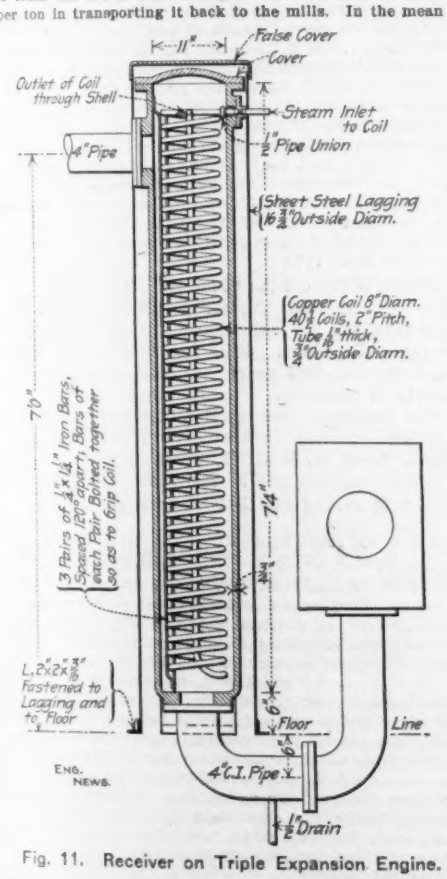

11"
False Cover
Cover
Outlet of Coil through Shell
Steam Inlet to Coil
4" Pipe
½" Pipe Union
Sheet Steel Lagging 16¾" Outside Diam.
Copper Coil 8" Diam. 40½ Coils, 2" Pitch, Tube ⅛" thick, ¾" Outside Diam.
70"
3 Pairs of 1"x¼" Iron Bars, Spaced 12" apart, Bars of each Pair Bolted together so as to Grip Coil.
74"
L, 2"x2"x⅜" Fastened to Lagging and to Floor
6"
Floor
Line
6"
4" C.I. Pipe
½" Drain
Eng. News.

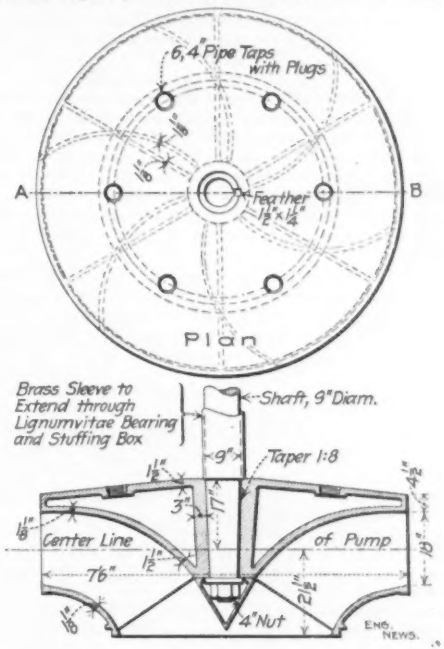
Fig. 11. Receiver on Triple Expansion Engine.

time the rail has lost from wear and rust from 3 to 6% of its weight. How much of this cycle of operations is chargeable to operating expenses and how much of it should be taken into account in finding the physical value of the property? To further complicate the matter, only a small per cent. of the rail ever finds its way back to the market as scrap. After a varying number of years of service, in the main line track, it is taken out and loaded and sold to another road to be delivered f. o. b. cars at the extreme point of the system in the direction toward which the purchaser wishes to use the rail; or it is taken to a secondary line of the system to remain an indefinite number of years in the track, eventually to be removed into an unimportant siding or spur track where its term of probable service cannot be determined from any records that we now have. To show the importance of a correct basis for deciding this matter: If we take the mileage of all railway track in the state at 10,000 and the average weight of rail to be 60 lbs. it will be seen that an error of even $1 per ton in the assumed price would affect the appraisement of the physical property of all the railways of the state by nearly a million dollars.

In the assumed standpoint that the physical property of a given road is worth what it would cost to-day to reproduce it in its present condition, there is a seeming inconsistency in that it involves an impossible condition. It would not be possible to reproduce the road in its present condition even were it possible to erase it. If reproduced it must be made new in every respect; it must have new cars, new rail and a new roadbed. To carry out the intent of such a rule it is necessary to figure, in finding the cost of reproduction, everything new, and make an algebraic addition to this to gain the present value by estimating the effect of wear and time upon each item. Now the roadbed, the part of the road below the ties, or at least that part of it which rests on the solid earth, appreciates with time and use. Nearly every other article in the list of the physical property of a railway depreciates with time. Rail, bridges, ties, masonry, rolling stock, shops, and all other structures depreciate; the best masonry and steel bridges very slowly, ties and timber structures very rapidly, rail and rolling stock accordingly as they are put into hard or easy service. The land for the right-of-way, yards and terminals (like the traffic, which does not belong on the list of the physical property) may appreciate or depreciate with time. The masonry built by one road may be of such excellent quality that its rate of depreciation may practically be taken at zero. That of an adjoining road doing the same business may be so poor that it will deteriorate faster than timber structures. Thus the question of depreciation is as puzzling as it is important.

Even after a resurvey of the roadbed is made so that the earthwork quantities are known, it cannot be said at once just what unit prices ought to govern in figuring the cost of reproduction. The road may have been graded by casting dirt from the sides with a shovel or by hauling the material from the cuts to the fills by wheelbarrows or wagons. Probably very different methods of doing the same work would be used in constructing such a road to-day, so that in spite of the higher cost of material and labor the general cost of earthwork would probably (but not necessarily) be lower. The general cost of rock excavation, on account of the higher cost of labor and of material, particularly explosives, would probably (but not necessarily) be greater.

Thus at almost every turn the appraiser of the physical value of railway property is met by questions requiring special expert investigation before they can be answered. There is very little engineering literature to give information as to these questions, for although it is probable that almost every considerable railway property in the country has been appraised by experts at one time or another during its existence, the reports of these appraisements made for one railway expert by another, have not found their way into print. Even if they had, the standpoint from which these appraisements have been made was so entirely different from that here required, they would be of little value. The state of Michigan made, in 1900, such an appraisement of the railways of that state as the law here requires, but, though the results of the appraisal have been published, a full account of the means used to arrive at the results have not been published.*



Section A-B.

Fig. 10. Pump Runner.

The law provided for the employment, by the state board, of such engineers and accountants as might be necessary in assisting it to arrive at the value of the railway properties. Under this law the state board, early in June, appointed the professor of railway engineering at the state university as engineer expert to assist it in making the appraisal. In the same month the attorneys, tax agents, and chief engineers of a few of the large railways were invited by the state board to come to Madison to confer with the board and its engineer in regard to the plan of appraisement to be adopted. The roads included at this conference represented more than 70% of the entire mileage of the state.

It was suggested to the representatives of the roads that it might be the better plan for them to make up property lists and an appraisement of their own physical properties, to be handed in to the engineer of the board for examination, and such alteration as might appear to be necessary. Except for the expense to the roads in doing the work, this was a much better plan than that of having their property schedules made out by the engineers and employes of the state board. The roads represented

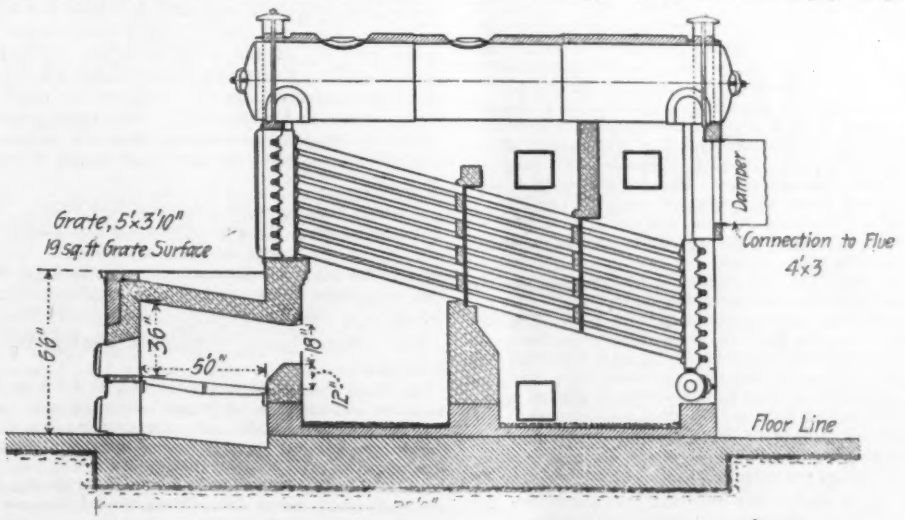


FIG. 12. WATER TUBE BOILER FOR SEWAGE PUMPING STATION.

*See an extended article, entitled "Expert Valuation of Railway and Other Corporate Property in Michigan," in Engineering News of Dec. 20, 1900.

accepted the suggestion and then a general plan of appraisement was discussed at length at this and other conferences, till most of the disputed points were agreed upon by the board and the roads.

The plan of appraisement was then drawn up and printed over the signature of the board's engineer, and copies of it were sent to all the departments of each railway which undertook to make out its own appraisal. Under this plan the engineer of the board furnished the blanks for enumerating and evaluating all the property in each department of a railway. The blanks are furnished in sufficient number for the railways to keep such copies of their returns as they wish. In order to facilitate the checking of the property lists by the board's engineer or his assistants, it was arranged that each road shall divide its track up into numbered sections. All fixed property of a road within the corporation lines of large towns shall constitute one section, and a complete set of blanks shall be made out exclusively for each section. No track section is to exceed 50 miles in length. Under this arrangement the two large systems before referred to have divided their track in the state, one into 81, and the other into 76, sections.

After these arrangements were made with each of the large roads represented at this conference, one road after another in the state was approached, and finally all roads in the state having an organized engineering department, agreed to undertake the appraisal of their own physical property under this general plan, and some of the smaller roads which did not have an organized engineering department, in order to be in line in the matter, employed engineers to get up the information. The work was begun in July, and although one of the large systems had seventy men at work at one time on their appraisal, no one of the larger roads of the state had, on Dec. 1, completed the appraisal of its property.

There were several smaller roads in the state which had no engineering force, and which could not afford to employ extra help to compile the information. As the aggregate mileage of these smaller roads was considerable, it was necessary, in order to appraise them, as well as to check and unify the appraisement of the larged roads, for the state board to organize a considerable engineering force. Further, it was early decided that the state board would make an independent investigation of the value of the right of way lands and terminal properties, and of rolling stock, shops and machinery.

An engineer office for the state board has been established in the engineering building of the university. Some thirty men, all told, have been employed in this work, and at the present time (Dec. 1) sixteen are still working. In the appointment of this force fitness alone for the work has gained the men their positions. Not one man has been appointed through political favoritism, and, be it said to the credit of Wisconsin's politics, and especially to the honor of the state board of assessment, there has not been a single application to the engineer of the state board, backed with even the shadow of an attempt at political pressure. Even residence in the state has not been considered in the appointments. Men have been engaged for this work wherever the men could be found who were especially adapted for it. They have come from New York State, Pennsylvania, Tennessee, Arkansas, Michigan, Illinois, Missouri and Winnipeg, Canada, as well as Wisconsin.

Some of the appointments have been as follows: Mr. John Marston, Jr., is principal engineer inspector; Mr. E. S. Fraser is first assistant inspector. Field engineer inspectors are Mr. E. A. Wilder, Mr. J. M. Larned, Mr. W. Vandercook and Mr. Louis Shaw. The chief land inspector is Professor E. B. Skinner of the department of mathematics of the state university. The chief mechanical inspector is Mr. J. G. D. Mack, professor of machine design in the state university. Under Professor Mack are: Mr. Horace Mann as mechanical inspector, Mr. Henry Harvey as locomotive inspector, and Mr. J. K. Woolley as car inspector. Each of these men has efficient assistants working with him.

So far there has been no friction whatever between the railroads and the state board and its employes. The utmost courtesy has been shown on both sides. The employes of the state board are endeavoring to secure as fair and accurate an estimate of the physical values as the difficult problem will admit of, and since the majority of the railroads seem to be no less willing to give all necessary information and to have their property fairly accounted for, it is to be hoped that the forthcoming appraisal of the railway physical values will give satisfaction throughout the state.

(Supplementing the information given in the above paper, Professor Taylor has kindly supplied some additional notes on the progress of this appraisement, and has also sent us copy of the Wisconsin Act, under which the assessment was carried out, a copy of the printed instructions drawn up by him to govern the conduct of the appraisement, and copies of the blank appraisal forms used.

The Act under which the work was carried out is a general tax law for railway property in the State of Wisconsin, providing also the machinery and powers for carrying the taxation and the precedent appraisal into effect. As vitally concerning the work of appraisement, we give the essence of some of the provisions of the Act:

The Board (see beginning of paper above) shall "make an annual assessment of the property of all railroad companies within this state for the purpose of levying and collecting taxes thereon." The property to be assessed "shall include all franchises, right-of-way, roadbed, tracks, stations, terminals, rolling stock, equipment and all other real and personal property used or employed in the operation of the railroad or in conducting its business, and shall include all title and interest in such property as owner, lessee or otherwise." A very important provision is that "Street railways are excluded from the operation of this act."

The Board of Assessment is decreed to have access to all books, documents, accounts, etc., on file in any departmen of the State or of counties, towns, cities, etc., and may require any returns of information from the officers in charge of such documents. It may compel the attendance and testimony of witnesses, and shall have access to all records, books, papers, etc., of railways. All railways are required to make annual reports of status, officers, financial condition, real and personal property (general description only), length of line, earnings and income by months, directors' reports, etc., and "such other facts and information as said Board may require in the form of returns prescribed by it." Refusal or neglect of performance by any railway will estop the railway from questioning or impeaching the action of the Board.

The Board is charged with determining each year "the true cash value of the property of each railroad company within the state," and in the case of railroad companies owning or operating railroads lying partly within and partly without the state, "the Board shall only value and assess the property within this state," which may be done on the basis of mileage within and without the state together with such other circumstances as the Board may deem pertinent.

Upon the results of this valuation of railways by the Board, is based a tax which shall be at a rate equal to the general tax rate for the State; this latter is to be found by ascertaining "the aggregate tax in the whole state for state, county and local purposes" levied on "all real and personal property appearing upon the assessment rolls and tax rolls throughout the entire state upon which the state, county and local taxes are levied and collected." There is also provided for the years 1903, 1904 and 1905 a license fee to be paid by each railroad, of an amount equal to from 2 to 4% of the gross earnings, depending upon the rate of earnings per mile; but the license fee forms part of the tax payment provided as noted above, and if the tax as subsequently determined is the smaller amount, then the excess of the license fee is to be refunded to the railroad company.

Finally, the Board is empowered to employ "an expert engineer, an expert accountant and such clerks and assistants as may be necessary . . . and to fix their compensation." The salaries and the expenses of the work are paid out of the treasury of the State.

The addenda supplied by Prof Taylor, are as follows:)

The above article was written by request for a college magazine and was expected to have principally local readers, but it outlines briefly and correctly the appraisal of the railway physical properties now being made in Wisconsin.

It would be improper in an article intended for the engineering public not to acknowledge the indebtedness of the State Board and its engineer to Prof. M. E. Cooley, of the University of Michigan, who, as noted above, made a similar appraisal in 1900 of the railway properties of Michigan. Professor Cooley was consulted in the beginning of the work as to the general plan to be pursued, and kindly furnished much information and many samples of blank forms used in the Michigan appraisal.

The idea of asking the railways to have their own officers make and submit an appraisal of their physical properties, however, was conceived by noting the fact that when the Michigan authorities had their experts to appraise the railway properties some of the railways had the same thing done on their own account by their own employees in order to check the appraisement. And since the railways would probably do this in Wisconsin the board of assessment could probably secure a more accurate appraisement by getting the roads to do this work first and having them submit their notes, prices, and property lists to the State Board for final review by its own engineers and employees. The high character of the chief engineers of the railway companies under whose direction most of the work was to be done, was a sufficient warrant that such work would be done faithfully and more accurately than was possible by any experts not familiar with the properties, and to whom the form of records kept by many of the companies would be new.

Since the above article was written nearly all of the roads of the state have completed and sent in their appraisements to the State Board. These reports are now being reviewed in the Board's engineering office, but the results have not yet been made public. The results, however, have justified the means adopted. The work has been done efficiently and well on the whole, the roads generally co-operating with the Board in getting their property properly accounted for in a way that is both pleasant and creditable. In a great many instances the roads have returned parts of their properties at values exceeding the figures on the same property by the employees of the State Board. For example, the most valuable terminal property in the state is that of the Chicago, Milwaukee & St. Paul Ry. Co., in Milwaukee, which road owns more than 500 acres in and about that city. Under the plan of appraisement adopted in order to value this property it was necessary to determine the market value for other purposes of this land used for terminals and right of way. (See plan of appraisement printed below.) Both the railway and the employees of the State Board made a separate investigation by entirely different plans to arrive at the market value of this land. In the valuation of this property worth several million dollars the two findings differed by about 3.5%, the railway having the higher figure.

Perhaps the greatest objection that can be urged against the plan pursued is that it places the burden of the expense of the appraisement, which expense amounts to not less than six or seven dollars per mile of road, on the railway companies, who certainly are not expected to derive any very great pecuniary benefit therefrom.

In Art. II. of the printed plan of appraisement (reprinted below) it will be noticed that the words "condition percent" and "value in percent of new" are used in the same sense. Most of the blanks call for the listing of the property in "condition percent," but some of them, as that for "locomotives," call for the property to be listed in "value in percent of new." This difference in wording was unfortunate and caused some confusion in the property returns. For property which has no scrap value, as cross-ties or ballast, the two terms mean exactly the same thing. But for property such as locomotives and steel rail the terms mean quite different things. For example, the "condition percent" of the steel rail described in the paper reprinted above is plainly 40, while its "value in percent of new" is 70.

(Below is printed the "Plan Adopted" which was drawn up by Prof. Taylor. The blank forms referred to are too voluminous for us to attempt to reproduce them. They are of standard size, 8½ × 14 ins., and cover separately the different classes of property. Smaller forms, not supplied to the railways, were used for reporting selected opinions of land values. The Final Summary Sheet, form W. B. A. 101, gives an idea of the classification adopted in the work, and for that reasón is reproduced herewith.—Ed.)

PLAN ADOPTED FOR FINDING THE PHYSICAL VALUE OF WISCONSIN RAILROADS.

I. COST OF REPRODUCTION.—The first step required in the appraisement of a road will be to get the cost of reproduction of the physical properties of the road. The several items comprising the physical properties of the usual railway are enumerated from 1 to 37 on the sheet W. B. A. Form 101, which sheet also shows certain fixed percentages to cover certain items. The cost of reproduction is assumed to be what it would cost to reproduce the road at the average prices prevailing for the period of five years ending June 30, 1902, entirely new in every particular, in, say, two or three years' time, if the entire railroad were eliminated—its right of way, yards, stations and terminals passed into other hands and occupied by just such woodlands, waste lands, farms, industries and residences as those now existing in and on the adjoining country and property.

II. PRESENT VALUE OF THE PHYSICAL PROPERTIES.—The second step shall be to obtain the present value of the physical properties. By the present value of a road is meant an amount which equals the cost of its reproduction minus an amount covering the depreciation in value from time, wear, etc. Thus the cost of reproduction and the present value of the land on which the road's right of way and terminals are located are the same, but the cost of reproduction and the present value of steel

rails are likely to be quite different. Thus, if the market value of new steel rails is $28 per ton, and the scrap value $12 per ton, the wearing value is $16; and if at the present time 40% of the life that the rail can be used in the roadbed has been used up, the rail is in 60% condition, and its present value per ton would be $12 plus 60% of $16, or $21.60 per ton.

In the determination of the present value of the property the field notes taken for making this appraisal must be very carefully made, and the condition of each item of property must be recorded in the field as a percentage of maximum efficiency, or in what is sometimes called "the value in per cent. of new." This "condition percentage" should never be omitted and should be written on the accompanying blanks after the description of each article in case there is no space on the blanks for its insertion. In important structures, such as a steel bridge or roundhouse, it would be better to give the condition percentage of the important parts of the structure. Thus the masonry of the bridge may be in 90% condition and the superstructure in 60% condition.

III. DETERMINATION OF LAND VALUES.—In finding the value, for the purposes of this appraisal, of the land (exclusive of the improvements constructed by the railway company) for the right of way, yards, station grounds and terminals, the land shall be divided into the following classes:

Class 1. Barren lands.

Class 2. Farming lands.

Class 3. Land in villages of less than 500 people.

Class 4. Land in cities and villages of between 500 and 3,000 people.

Class 5. Land in cities and villages of between 3,000 and 10,000 people.

Class 6. Land in cities of over 10,000 people.

Barren lands are lands nearly or quite worthless for crops, hay or grazing.

In this appraisal the value of the land for other purposes must be determined by getting as accurately as is reasonably possible the average value at the various county seats as shown by the records of the transfers of property for the five-year period ending June 30, 1902, in the section traversed by the road; and by consultation with disinterested, local, reliable real estate and business men, bank cashiers, etc. Form W. B. A. 7 has been prepared with some care to be used in getting statements of the market value of land from disinterested persons along the line of road. These cards should be used freely so as to get as many reliable opinions as possible as to the important question of land values.

THE RIGHT-OF-WAY-VALUE.—The correct valuation of the land held by the railway for right-of-way, yards and terminals is one of the most important as well as one of the most difficult tasks in finding the physical values. The term right-of-way is intended to include the land for stations, yards and terminals.

Two distinct results should be obtained as provided for in the last two columns on blank Form W. B. A. 4; namely, first, the market value per acre of the land for other purpose, and, second, the value per acre as right of way. The first is to be obtained in the manner explained above. The second should be obtained by taking the average market price for other purposes of the land actually within the right of way and by adding thereto the damages to the adjoining property forming a part of the same parcel which are directly attributable to the proper construction and operation of the railroad across that portion of the land taken.

The strip of land usually taken for railroad right of way is not generally along or parallel to the boundaries of the land. The proper construction of the road often makes access from the land on one side to the land on the other side more difficult, and such access at more than one crossing is often impossible on account of right-of-way fences, deep cuts or high fills. The natural drainage is oftentimes interfered with. Roads and streets may be closed or changed. The noise, smoke, danger and inconvenience from the operation of railroads may not be distinct subjects of damage, yet in so far as they depreciate the market value of the remainder of the premises they should be considered. These considerations always make the right-of-way value more, oftentimes much more, than its market value for other purposes.

To determine the value of the land in the present right of way, such lands must be deemed as belonging to the owners of the adjoining lands and to be acquired by negotiations with such owners or under the power of eminent domain whereby the owners are entitled to just compensation for the land actually taken and for the depreciation in the market value of the residue in consequence of the railroad crossing the part taken. In ordinary language, the inquiry will be first, what is the fair average market price per acre for ordinary purposes of the land taken, and second, how much is the depreciation in the salable value of the residue of the parcel, lot or tract with the buildings thereon from which the right of way is severed. The sum of the two items, first, the market price of the land taken, and, second, depreciation in the salable market value of the residue, will constitute the right-of-way value.

The right-of-way value per acre may be ascertained and determined by agreement between the agents of the railway company and the owner, on the above basis, at the five-year average market price per acre for the land within the right of way, plus the depreciation in the market value of the residue not taken, the parties knowing that the land is to be used for railway purposes and being disposed to agree upon a fair, reasonable and just sum as the price of the land and the damages to the land of which the right of way was a part.

In determining the value of land for other purposes within the right of way, such value will be ascertained by taking the market value of the bare land without including the value of buildings. To this value of the right of way will be added the depreciation of the market value of the residue from which it is taken, and this will include the depreciation not only to the land itself, but to any buildings that may be upon such lands.

Thus, suppose that the value of a quarter section of farming land without the buildings is $50 per acre for ordinary purposes, and that the railway takes three acres of this land as a right of way. Suppose the market value of the remaining part of the quarter section with the buildings thereon is depreciated $225 by the construction and operation of the railroad across the three acres taken for right of way. Then while the value of three acres for other purposes is only $150, or $50 per acre, the depreciation to the residue of the farm will bring the price actually paid for the three acres of right of way up to $375, or $125 per acre, the right-of-way value being in this case 250% of the market value for other purposes.

While the market value of land for ordinary purposes can be ascertained with a reasonable degree of certainty, the depreciation in the market value of the adjoining land by the construction of railroads is in many cases under present conditions difficult to determine with even approximate accuracy. It is also difficult to fix upon a uniform ratio to be applied in all cases. But each officer in charge of the land appraisal work should fill in in the computing office the column "Right-of-way value," on form W. B. A. 4, establishing such a ratio between the market value and the right-of-way value as his experience and information lead him to believe is fair.

It should be remembered that the land belonging to railways not used for purposes of transportation and traffic does not fall within the scope of this appraisal.

IV. GRADES AND CURVES NOT CONSIDERED IN THE VALUATION.—In this appraisement no attempt will be made to take into account the economic value of grades and curves or the absence of them; that is, each road will be appraised just as if it were a straight line and as if its grade line were level throughout.

V. INDUSTRIAL TRACKS.—In this appraisement the roadbed and tracks, grading, bridges, culverts, etc., of all "industrial tracks" operated by a railway company shall be scheduled as the property of the railway company except where it can show that such property does not belong to the company; but the right of way and adjacent buildings shall not be so scheduled unless the railway owns them outright.

VI. APPORTIONMENT OF ROLLING STOCK OF INTERSTATE ROADS.—The amount of the rolling stock and miscellaneous equipment to be credited to the State of Wisconsin will be found by finding first the number of all the different classes of locomotives, passenger and freight cars, and miscellaneous equipment of the whole system; then the number of each class of Wisconsin locomotives, passenger cars and freight cars shall be apportioned in the same ratio as the annual locomotive, passenger car and freight car mileage of the whole system in Wisconsin bears respectively to the total annual locomotive, passenger car and freight car mileage of the whole system in all states. The actual value of special equipment exclusively used in Wisconsin is to be specifically ascertained; but such equipment as wrecking outfits, steam shovels, etc., which is used both in and without the State, shall be pro rated according to the same ratio above described for rolling stock or in the ratio of the time in use within the State to the whole time in use within and without the State.

If in any case for any reason the mileage record cannot be ascertained on which to base this calculation, the apportionment for rolling stock shall be pro rated in the same ratio as the total length of track in Wisconsin—including main line, branches, second track, spurs and sidings—bears to the total length of track of the entire system.

In arriving at the "percentage condition" of rolling stock on large interstate roads, there shall be indiscriminately inspected at convenient points or terminals within or contiguous to the State 50% of each class of the road's locomotives and 50% of each class of the road's passenger service cars in actual use, wholly or partly, in Wisconsin, and the average percentage condition so obtained shall be taken to represent the condition of the whole class of cars or locomotives.

The "percentage condition" of each class of freight cars shall be established similarly by actual inspection of not less than 20% of as many cars of each class of the road's cars as the company's books show should be apportioned to Wisconsin under the above rule of apportionment. The forms W. B. A. 60, 63, 64 and 65 should be carefully filled out and signed by competent inspectors, showing that a careful bona fide examination of the rolling stock has been made. In the inspection of freight cars the inspectors should work in pairs, and in order to identify cars that have already been inspected, the inspectors should carry hammers with which they can imprint with a blow the initials "W. B. A." on the needle beam of the car. As large a proportion as possible of the rolling stock of the smaller roads operating entirely within the State should be inspected. No attempt should be made to determine in the field the actual value of rolling stock, but the actual value for each class should be determined from the records of the usual actual purchases or by reliable information secured from reputable manufacturing concerns as to the market value.

VII. DETAILS OF THE COMPILATION.—In this appraisal detailed sheets provided for the purpose shall be prepared, enumerating as far as possible the amount and condition of all of the physical property of the company.

In arranging the blank forms for this appraisal the form numbers W. B. A. 1-29, inclusive, have been used for itemizing property generally within the province of the engineering department; the numbers 30-59, inclusive, are used for property generally within the province of the bridge and building department; and the numbers 60-89, inclusive, for property within the province of the motive power, machinery and car service departments of the ordinary railway; and the numbers 100-101 have been used for the summation blanks. In preparing the information to go on the forms from 1 to 90 it is not contemplated that the actual money value of the property shall be shown, but only such a description of it and its condition is to be given as will enable its value to be compiled in the office in detail and with uniformity on Form 100.

It has been found almost impossible to provide blanks for all the classes of property, but the field inspectors should carry the usual blank pocket note books, and all property not provided for on the blanks should be itemized and valuated on Form 100. No blanks can be of service in valuating such items as Track Laying and Surfacing, Transportation of Materials during Construction, etc., but all such items should be enumerated and included on Form 100.

This Form W. B. A. 100 is of the utmost importance in this appraisal. The information shown on Forms 1-90 is of service only to help in fixing with greater accuracy and fullness the enumeration and valuation of the property on Form 100. This form will be used to itemize and valuate all of a road's fixed property at important points or terminals; to itemize and valuate all property on sections of the line of road not to exceed, say fifty miles in length; and to enumerate and valuate the rolling stock and special equipment. To make the matter clearer, take as an example the line of the Chicago, Milwaukee & St. Paul Ry. from Madison to Milwaukee. As many as may be necessary of each kind of blank from 1 to 90 will be used to describe all the property of the St. Paul road within the city of Madison, and the Madison property will be

W. B. A. FORM 101.

Wisconsin Railroad Appraisal of 190..
Name of Road.....
Location .....
Date of Compilation.....190..
Compiled by .....

FINAL SUMMARY SHEET.

Miles of Main Line.....
Miles Branches.....
Miles Second Track.....
Miles Spurs and Sidings.....

VALUE OF PHYSICAL PROPERTIES.

Subject	Cost of reproduction.	Present Value.
1. Right-of-Way and Station Grounds...	....	....
2. Real Estate	....	....
3. Grading	....	....
4. Tunnels	....	....
5. Bridges, Trestles and Culverts.....	....	....
6. Cross Ties and Switch Ties.....	....	....
7. Rails	....	....
8. Track Fastenings	....	....
9. Frogs, Switches and Crossings.....	....	....
10. Ballast	....	....
11. Track Laying and Surfacing.....	....	....
12. Fencing	....	....
13. Crossings, Cattle Guards and Signs..	....	....
14. Interlocking and Signal Apparatus....	....	....
15. Telegraph Lines	....	....
16. Telephone Lines	....	....
17. Station Buildings and Fixtures.....	....	....
18. Shops and Roundhouses.....	....	....
19. Shop Machinery and Tools.....	....	....
20. Water Stations.....	....	..
21. Fuel Stations	....	....
22. Grain Elevators	....	....
23. Warehouses	....	....
24. Docks and Wharves	....	....
25. Miscellaneous Structures	....	....
26. Terminals	....	....
27. Engineering, Superintendence and Legal Expenses, 4.5% on all of the above items	....	....
28. Locomotives	....	....
29. Passenger Equipment	....	....
30. Freight Equipment.....	....	....
31. Miscellaneous Equipment	....	....
32. Ferries and Steamships	....	....
33. Electric Plants	....	....
34.		
35.		
36. Interest During Construction, 3%; Organization, 1.5%; Contingencies, 5.5%; in all, 10% on all of the above items	....	....
37. Stores and Supplies on Hand for Use in Wisconsin	....	....
Totals	....	....

itemized and valuated on as many of the No. 100 forms as may be necessary. An entirely independent set of blanks will describe, enumerate, and valuate all property along and on the line of road from the east corporation line of Madison to the west corporation line of Watertown. Another independent set will be used for the Watertown property. Another set for the property from the east corporation line of Watertown to the west corporation line of Milwaukee; and still another independent set for the Milwaukee property of the St. Paul road.

In itemizing on Form 100, the accounts 1 to 37 (See Form 101) should be taken in order and all the items under each account over the given territory should be enumerated before taking up the next account.

Before beginning the work of inspection and compiling, the officers in charge of the appraisement of each road should agree upon the division of the section and terminal points to be used, and should issue instructions to the inspectors and compilers to the end that each set of blanks may be filled in only with information pertaining to one terminal point or section.

A good deal of time has been spent in trying to arrange a printed itemization for all the property that is to be shown on this Form W. B. A. 100, but it was found that railway property is of so many different kinds and conditions that the printed headings would make the form so long as to seriously impair its usefulness. The form has been made of a size that can be used on a wide carriage typewriting machine, the lines being delicate and the same distance apart as the usual typewriter spacing so that the form can be filled in by hand or machine as may be preferred. The blanks are printed on paper thin enough to secure three manifold copies.

Form W. B. A. 101 will be used in summing up the values given on Form W. B. A. 100 for a line of road between important points within the State; for summing up the values for all of a division of a road within the State; and for summing up the values of all of a whole system within the State, including the rolling stock, etc.

W. D. Taylor,
Engineer, State Board of Assessment.

PITOT TUBES; WITH EXPERIMENTAL DETERMINATIONS OF THE FORM AND VELOCITY OF JETS.*

By James E. Boyd,† and Horace Judd.‡

These experiments were begun to determine the value of the constant of the Pitot tube in the equation $V = K\sqrt{2gh}$ and the variation of this constant with change in the form of the tip. Prof. S. W. Robinson,[1] in 1886 and earlier, using Pitot tubes, .065-in., ¼-in., and 7/16-in. in diameter with sharp-edged tips, found the constant to be practically unity. Mr. John R. Freeman,[2] in 1889, made use of a carefully constructed Pitot tube .006-in. internal diameter and .017-in. external diameter, with blunt tip, in the measurement of the velocity of water from a fire-engine nozzle under a pressure of 50 lbs. per sq. in. He found the constant to be unity within 1% certainly and probably within less than ¼ of 1%.

Other experimenters, however, have obtained quite different results. It has been claimed that the pressure in a Pitot tube may be $\frac{v^2}{g}$ instead of $\frac{v^2}{2g}$. The reason for this is found in the fact that a stream of fluid striking a surface sufficiently large to destroy all its motion in the original direction exerts a pressure on the surface equal to $\frac{v^2}{g}$ times the area of the stream. When the area of such a surface is diminished, only a part of the original velocity is destroyed and the total pressure is correspondingly reduced. The change of velocity normal to this surface of the mass of fluid which flows past any section in unit time, while it forms a part of the column having the surface as its base determines this pressure.

It is easy to see that a continuous stream striking normally on a plane surface equal to its cross-section cannot be reflected parallel to that surface; for, as soon as its normal velocity is diminished its cross-section is increased, and part of the fluid is pushed out of the column having the surface as its base. Consequently the pressure in a Pitot tube can never be as much as $\frac{v^2}{g}$. A simple experiment in this connection is interesting. In front of a one-inch short pipe we placed a round iron bar the end of which was nearly plane and found that the reflected stream formed a cone the angle at the vertex of which was a little less than 120°. This means that the jet lost about one-half of its original velocity.* The ingenious experiment of Mr. W. M. White,† who measured the pressure at different points on a plate against which a stream of water was striking, brings out the same point in a different way.

It seems possible, however, that the change of velocity with respect to any surface may depend somewhat on the form of the adjacent surfaces. If such be the case, variation in the form of a Pitot tip such as is shown at a, b and d, in Fig. 3, should cause a change in the pressure exerted by the moving liquid on the liquid surface at the mouth of the tube. To determine this question we applied variously formed Pitot tubes to the jet flowing from an orifice in a thin plate. The arrangement of apparatus was that shown by Fig. I. The water flowed from a drum 2 ft. in diameter in which the head was kept fairly constant by means of a pair of pumps. The pressure in the drum was measured by means of a piezometer connected at the top and at one side, as shown in Fig. 2, the connection being provided with a relief cock by means of which any air might be allowed to escape. The Pitot was connected to a glass tube placed beside the piezometer for measuring the static pressure. Each of these glass tubes was ⅛-in. inside diameter.

TABLE I.—Readings in Jet from 2-in. Orifice.

Distance in ins. from center of Pitot to axis of jet.	Pressure in feet of water. Pitot.	Static.	Ratio.	
0 to .500	.....	.....	.999 to 1.000	
.550	4.120	4.145	.994	
.600	4.145	4.170	.994	Plane of orifice.
.650	4.110	4.235	.970	
.700	4.075	4.230	.963	
.750	3.910	4.200	.931	
.800	3.800	4.180	.909	
.200	4.257	4.260	.999	
.300	4.350	4.350	1.000	
.400	4.280	4.325	.990	.2-in. back of orifice.
.500	4.307	4.338	.993	
.600	4.060	4.120	.985	
.700	4.132	4.332	.956	

No great care was used in taking the readings of Table I. so they are only approximate.

TABLE II.

Angle.	Micrometer readings Right.	Left.	Sum.	Diameter sum ÷ 1.974.
0°	1.299	1.253	2.552	
	1.307	1.247	2.554	1.179
	1.307	1.246	2.553	
15°	1.307	1.245	2.552	
	1.309	1.248	2.557	1.181

The Pitots first used were made of seamless copper tubing 5/16-in. outside diameter and 1 1/8-in. inside diameter. One of these is shown complete at e, Fig. 3, and the tips of two others at f and g. That shown at e had the end finished square; f was bellmouthed, and g was tapered on the outside. In each the plane of the tip was made normal to the axis of the end of the tube as nearly as could be determined by means of a machinist's square.

These Pitots were placed successively near the middle of a jet flowing from a 1-in. orifice under heads of from 2 to 6 ft. In each case the height of the water column in the glass tube connected to the Pitot was the same as the static head to within .002 ft. Tips a and b, old Pitot tubes which have been in the laboratory for years, were tried with the same results.

We next tried a pair of Pitots made of glass tubing, 0.162-in. inside diameter and 0.266-in. outside diameter. Of these, c was made by filing the full size tube as nearly normal to the axis as possible, while for d the tube was drawn down to an outside diameter of 0.011-in. and an inside diameter of 0.007-in. and then finished in the same way. These tubes also gave readings exactly the same as the static head. As it took some time for enough water to flow through the small mouth of d to materially change the height of the large column in the measuring tube, these readings lagged behind those of the static tube, being higher when the pressure was falling and lower when it was rising. When the pressure was kept stationary long enough the two columns were found to read practically alike.

Some time later we constructed the Pitots shown at h, i and j. The last was made of a brass rod in which a hole 0.040-in. in diameter was drilled, and the end turned to a taper having a very sharp edge at the mouth. This rod was soldered into the end of a piece of 3/16-in. tubing, forming the rest of the Pitot. In the jet from a 2-in. orifice it gave readings, .005-ft. lower than the static head. We were not sure in this case, that the tip was exactly plane.

Pitot h was made of a piece of 1/16-in. copper tubing of 1/32-in. bore. This was soldered in a piece of ⅛-in. tubing, which in turn was fastened to a piece of 3/16-in. tubing. Tube i was made in the same way, but the end was flattened reducing

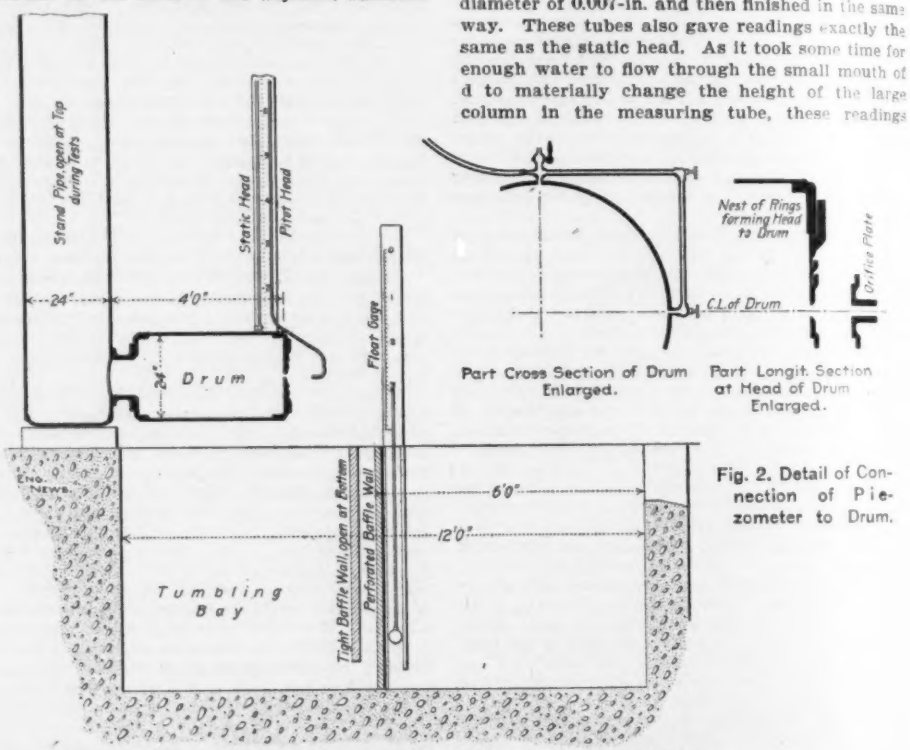


Fig. 2. Detail of Connection of Piezometer to Drum.

FIG. 1. GENERAL ARRANGEMENT OF APPARATUS FOR TESTING PITOT TUBES.

*A paper read before Section D of the American Association for the Advancement of Science, Dec. 29, 1903.
†Associate Professor of Applied Mathematics, Ohio State University, Columbus, O.
‡Assistant Professor of Experimental Engineering, Ohio State University, Columbus, O.
[1]Van Nostrand's Engineering Magazine, August, 1886.
[2]Transactions American Society of Civil Engineers, 1889, Vol. XXI.

*The word velocity is used in its vector sense.
†Journal of the Association of Engineering Societies, August, 1901.

TABLE III.

Dist. from orifice in ins. / Angle with horizontal.	.750	.800	.850
	Mean diameter in ins.		
0	1.179	1.180	1.177
15	1.181	1.178	1.176
30	1.180	1.180	1.181
45	1.176	1.181	1.181
60	1.176	1.178	1.178
75	1.182	1.179	1.179
90	1.181	1.179	1.172
105	1.181	1.176	1.178
120	1.180	1.176	1.176
135	1.183	1.175	1.174
150	1.186	1.179	1.179
165	1.186	1.179	1.179
Mean	1.1808	1.1783	1.1775
Ratio*	.7835	.7819	.7814

*Ratio of diameter of jet to diameter of orifice.

TABLE IV.—Diameter of Water Jet from a 1.9975-in. Orifice in a Thin Plate.

Distance from plane to orifice in ins.	Diameter of jet, ins.	Ratio of diam. of jet to diam. of orifice.
.100	1.802	.902
.150	1.764	.883
.200	1.727	.864
.220	1.718	.860
.250	1.699	.8505
.300	1.681	.8415
.400	1.646	.824
.500	1.621	.8115
.600	1.606	.804
.700	1.592	.797
.800	1.586	.794
.900	1.580	.791
1.000	1.573	.7875
1.050	1.568	.785
1.100	1.568	.785
1.150	1.570	.786

TABLE V.—Diameter of Jet from 1.507-in. Orifice in Thin Plate.

Distance from orifice.	Distance from orifice in terms of radius.	Mean diameter of jet.	Ratio of diam. of jet to diam. of orifice.
.250	.332	1.251	.8301
.300	.397	1.236	.8201
.350	.464	1.224	.8122
.400	.531	1.214	.8057
.450	.597	1.201	.7969
.500	.663	1.199	.7956
.550	.730	1.196	.7936
.600	.796	1.190	.7898
.650	.863	1.190	.7898
.750	.995	1.1808	.7835
.800	1.062	1.1783	.7819
.850	1.127	1.1775	.7814

the horizontal inside diameter to .012-in. while the vertical inside dimension was increased to .017-in. The horizontal outside diameter was .045-in. at the end. In both h and i the tip was left blunt. Each gave readings in the jets equal to the static head.

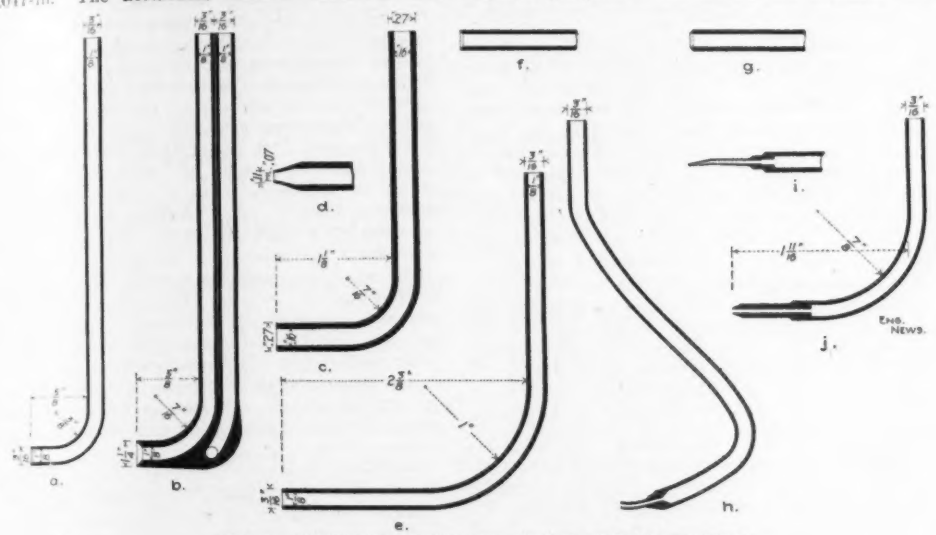


FIG. 3. VARIOUS FORMS OF PITOT TUBES TESTED.

We next tried the experiment of moving the Pitot horizontally or vertically across the jet. When this was done near the contracted vein, there was no change in the reading until the mouth of the Pitot reached the boundary of the jet.

We next moved the Pitot towards the drum, keeping it near the axis of the jet until the tip was behind the plane of the orifice and found, as Prof. Robinson had previously discovered, that there was no change in the readings, showing that the gain in pressure head exactly compensates for the loss in velocity head. When, however, the Pitot was moved away from the axis of the jet, either behind the orifice or a short distance in front of it, the Pitot readings fell below the static head. This is explained by the fact that the velocity is not exactly parallel to the axis of the jet and accordingly not quite normal to the mouth of the Pitot. Table I. gives some reading taken with Pitot h in the plane of the 2-in. orifice and 0.2-in. back of this plane.

Having found that the velocity pressure as measured by the different Pitots is practically the same as the static pressure in the drum back of the orifice we would naturally infer that the velocity of the jet is the theoretical velocity and that the Pitot constant is unity; for if there is some loss of energy in the water flowing from an orifice, it is hardly probable that the constants of the Pitots should differ from unity just enough to exactly compensate for it. In order to get an independent check it is necessary to make the following measurements:

1. Measure the diameter of the jet at the contracted vein.
2. Get Pitot readings as near as possible to the boundary of the jet at the contracted vein.
3. Determine the coefficient of discharge of the orifice.

1. Determination of the diameter of the jet at the contracted vein.

The mechanical laboratory is equipped with a piece of apparatus designed by Prof. Magruder for the purpose of measuring the diameter of a jet in any direction. A heavy brass ring is fitted in a groove at the head of the drum concentric with the orifice and held by lugs permitting free motion about the axis. Across the ring are two parallel rods on which a pair of carriages are moved by micrometer screws reading to 1/1000-in. On each carriage there is a second micrometer screw parallel to the axis of the jet. These screws move rods in the ends of which the contact points are placed. The contact points are brass rods curved so that the ends are nearly normal to the jet. In the first experiments these rods ended in sharp points. Later we filed them to knife edges about 1/16-in. long tangent to the section of the jet. The instrument was tested with a Brown & Sharpe vernier caliper and found to be correct. The screws for moving the points parallel to the jet were found to be not exactly parallel and the necessary correction was applied.

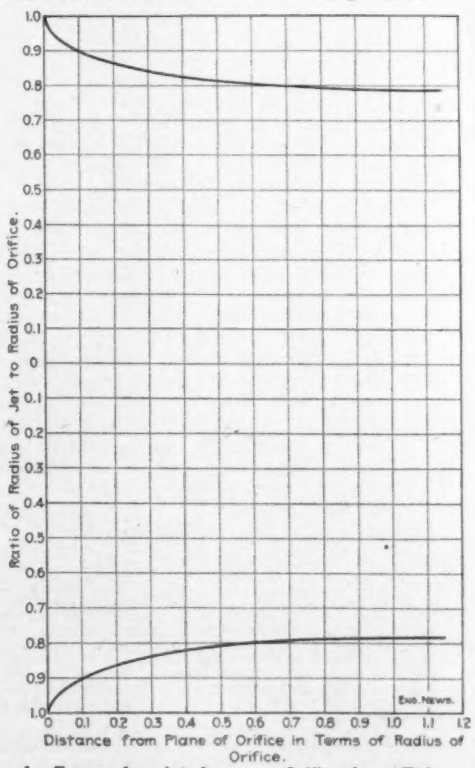


Fig. 4. Form of a Jet from an Orifice in a Thin Plate.

The jet from an orifice always vibrates and little ripples running obliquely around the jet are continually shifting about on its surface so that at a distance of one inch from the orifice the readings may vary as much as .01-in. In reading, we tried to get the position where the point was touching one-half of the time. To show how the readings vary we give in Table II. some figures from a cast-iron orifice 1.507 ins. in diameter at .750-in. from its plane.

Table II. may be taken as a fair sample of the way the readings run at this distance from the orifice. Farther away the variation is greater and nearer the orifice it is much less. Near the orifice we took our readings horizontally and vertically while about the contracted vein we measured in 12 directions at intervals of 15°. We give in Table III. the results for three positions on the jet from the 1.507-in. orifice.

In Table IV. we give the mean diameters of the jet from a 2-in. orifice the actual diameter of which is 1.9975 ins., and in Table V. we give the same for the orifice 1.507 ins. in diameter.

The form of a water jet is shown by Fig. 4. The upper curve is drawn from the readings of the 2-in. orifice alone, while for the lower curve the readings from both orifices are used.

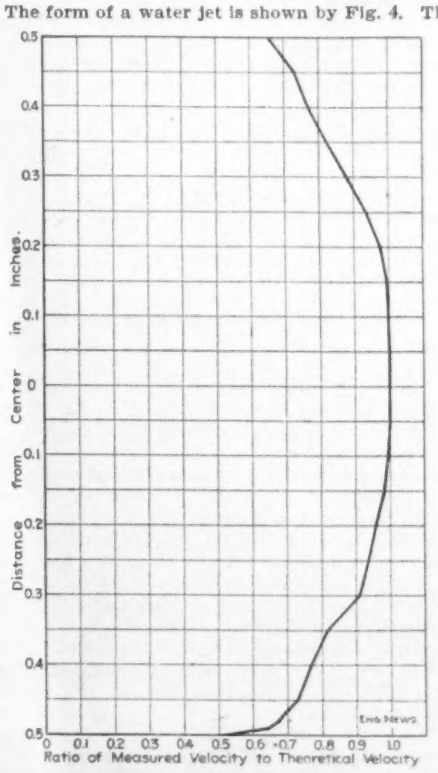


Fig. 5. Distribution of Velocity in a Jet from a Uniform Short Pipe, 1 in. in Diameter and 2 11-16 ins. long.

Taking .785 as the ratio of the diameter of jet

TABLE VI.—Pitot Readings near the Surface of a Jet from a 2-in. Orifice.

Distance center of Pitot to edge of jet, ins.	Pressure in feet of water. Pitot.	Static.	Ratio.	√Ratio.	Spray.
.030	4.410	4.410	1.000	1.000	
.020	4.393	4.400	.998	.999	30°
.010	4.318	4.383	.985	.992	
.000	3.650 to				
	3.500	4.390	.815	....	90°
—.010	2.100	4.420	....	....	150°

to diameter of orifice, we find the coefficient of contraction to be .6162. For the 1.5-in. orifice this ratio is about .782, making the coefficient of contraction .6115.

2. Velocity of Jet Near the Surface at the Contracted Vein.

When a Pitot tube was moved across a jet from an orifice in a thin plate near the contracted vein, the readings were constant until a point was reached where the jet no longer struck the entire mouth of the tube. To determine if possible whether there is any change in the velocity near the surface we took readings with our smallest tubes h and i on the 2-in. orifice. The results obtained by the use of i at 0.8-in. from the orifice are given in Table VI.

We do not know whether the decreased reading of the Pitot near the surface of the jet is due to a decrease of velocity or to the fact that the stream does not strike the entire mouth of the tube all the time. The first place where there is any considerable change is when the center of the tube is .010-in. from the surface. As the mouth of the tube was .012-in. wide, this brought the outer edge of the mouth only .004-in. from the surface, where owing to the fluctuations of the stream it was probably not entirely covered all the time. The variation of the stream was shown by a fine stream of spray about the size of the mouth of the Pitot tube which was reflected off when the outside of the tube projected out of the jet. The direction of this stream of spray varied considerably at each of the last positions and the Pitot pressure varied accordingly, being greatest when the angle of the spray with the jet was the least. The angles given in the table were estimated at the instant the corresponding Pitot reading was taken.

Assuming that the Pitot readings give the true velocity at the center of the tube, we have a mean velocity of .947 in the outer ring, .010-in. wide and .995 in the second ring. The jet here is 1.586 ins. in diameter. Computing the effect of this diminished velocity on the total flow, we find it to be less than 0.02 of 1% and may be neglected.

We believe that the velocity of the jet at the surface is little if any less than over the rest of the section for the reason, as Prof. Hitchcock suggested, that the stream is perfectly clear and shows no signs of feathering; while in jets where there is a difference in velocity, as in the case of nozzles, the more rapid water towards the center starts the outer layers to rolling, thus breaking them into drops and changing the appearance of the jet.

3. Coefficient of Discharge.

To determine the coefficient of discharge, the water flowed from the orifice into a bay of nearly 100 sq. ft. cross-section which has been carefully calibrated. The water level in the bay was measured by a float. The time required for the float to rise one foot was taken with a rated stop watch. The head in the drum was kept constant usually to within .01 ft., and readings were taken at regular 20 second intervals. The mean head was corrected for zero error and capillarity. 8.02 was used as the square root of g.

In this way with a mean head of about 5 ft. we got for the 2-in. orifice values of .6103, .6154, 6097 and .6099, and with a head of 4 ft., .6097, .6120, .6120 and .6108.

The mean of all is .6112.

With the 1.50-in. orifice under a head of 5 ft. we found .6127, .6095, .6122, .6123 and .6128 as the values of the coefficient of discharge. The mean for this orifice is .6119.

The coefficient of velocity for the 2-in. orifice is .6112/.6162 = .992.

For the 1.5-in. orifice it is .6119/.6115=1.0007.

Since the mean Pitot readings for all the section is the same as the static pressure to within a negligible quantity, the coefficient of velocity is practically equivalent to the constant of the Pitots.

TABLE VII.—Velocity of Water in Jet from Short Pipe in Terms of the Theoretical Velocity, Assuming the Pitot Constant to be Unity.

Distance from center in ins.	Velocity—Right.	Left.
.000	.9995	.9995
.050	.9985	.9987
.100	.9974	.9946
.150	.9926	.9816
.200	.973	.958
.250	.933	.936
.300	.878	.909
.350	.821	.817
.400	.768	.768
.450	.729	.728
.470	....	.688
.480	....	.674
.490	....	.645
.500	.654	.515

Pitot Constant:

From test on 2-in. orifice	.992
From test on 1.5-in. orifice	1.001

We next applied the Pitot marked h to the jet from a short pipe. The pipe was a carefully made one of cast iron 1.000-in. in diameter and 2$^{11}/_{16}$-in. long. The measurements given below were taken .02-in. from the end. Near the center the Pitot readings were nearly as great as the static pressure, but dropped to about one-fourth as much at the edge. They were steady near the central portion and fairly so near the edge, but at about 0.35-in. from the center they were subject to great fluctuations. We give some readings below.

Distance from center	.10	.20	.35	.45
Ratio of Pitot head to static head.	.904	.952	.656	.530
	.904	.953	.627	.532
	.904	.947	.611	.531
	.906	.937	.644	.534
	.906	.943	.715	.530
	....	....	.719	....
	....	....	.726	....
	....	....	.695	....
	....	....	.679	....

The mean value of the square roots of these ratios gives the velocity in terms of the theoretical velocity provided the Pitot constant is unity. It was found to be sufficiently accurate to take the square root of the average ratio instead of the average of the square root, so that in most cases the labor of computation was diminished by merely taking the square root of the ratio of the mean pitot to the mean static pressure. In Table VII. we give the results of one set of measurements.

The curve of Fig. 5 is plotted from Table VII., the upper part of the curve being from the right of the jet.

To determine the coefficient of discharge in terms of the Pitot readings the section of the jet was divided into 25 concentric rings each .02-in. wide, and the amount discharged by each ring computed in terms of its mean diameter and mean velocity. The velocity at the middle of each ring on each side of the center was taken from the curve. The mean of the two figures was multiplied by the mean diameter of the strip. The sum of these products multiplied by .02 and by π and divided by the area of the cross-section of the jet is the coefficient of discharge if the Pitot constant is unity. In this way from the figures of Table VII. we get the coefficient of discharge to be .830. The mean head during this experiment was 5.6 ft. A preliminary test made with a head of 4 ft. gave .8132, but as not enough time was given for the Pitot to come to its correct value, this is probably too low. The coefficient of discharge of this short pipe was found to be .8159 as the mean of 5 determinations.

The constant of the Pitot from these result is:

I.	.8159	+ .830	=	.983
II.	.8159	+ .8132	=	1.003
Mean of both				.993

Note.—In this calculation it is assumed that there is no static pressure in the jet in front of the tube, and that the pitot reading is the velocity pressure alone. As the stream diverges after leaving the pipe it is possible that there is some little static pressure in the free jet, in which case the coefficient of discharge computed from the Pitot readings is too large and the constant of the Pitot too small.

In like manner we assumed that there is no static pressure in the jet from the orifice in a thin plate at the contracted vein. As static pressure in a free jet is always accompanied by radial acceleration in some part of the section, and as we cannot see how there can be any radial acceleration at the contracted vein, we believe this assumption to be correct.

A number of readings were taken on another short pipe which was somewhat defective. Two sets of these were calculated and found to give .994 and .994 for the constant.

Freeman stated that the *particular* tube that he used measured high velocities in jets accurately to within less than 1%, and he believed to within ¼ of 1%, assuming the constant to be unity. Our results show that the same is true for low velocities and *any* Pitot the mouth of which is normal to the stream and which is curved smoothly a half-inch or so from the end.

We believe that the fact that the Pitot reading in the middle of a jet and the static pressure are the same is no accidental coincidence. We think that the velocity here is the theoretical velocity, in which case the Pitot constant is unity for free jets to within less than 1 part in 5,000.

We expected to continue these experiments in closed pipes and open troughs, but so far have been prevented by lack of time. The work of Gregory,[4] and White seems to have settled that matter however. They find that a properly constructed Pitot tube has a constant of unity whether used in a closed pipe or open channel.

Some observations which we made in the course of our work are of interest in this connection. We inserted Pitot in the end of the 1-in. short pipe and took readings at 0.2-in., 0.5-in. and 0.7-in. from the end and found that near the center of the tube these were the same as the static pressure. The same result was obtained with the flattened Pitot i. This would seem to indicate that the Pitot reads correctly in closed pipes with a constant the same as in the jets.

The work of Gregory and White was done with a large pipe in which the Pitot would make no appreciable difference in the velocity. It is a question whether the Pitot reads the velocity of the clear section above its mouth or that of the diminished section at the side. In the latter case we should expect discrepancies in small pipes where the size of the pitot appreciably affects the cross-section.

We tried a few experiments of moving the Pitot in still water. The Dept. of Civil Engineering has a track running over the power house reservoir for the purpose of testing current meters in this way. We attached Pitot a to the car that runs on this track, and pushed it over a measured distance of 50 ft. with as nearly uniform velocity as possible, being careful to get it up to speed before reaching the beginning of the 50 ft.

As the water level at that time was some distance below the track it was thought more convenient to raise the level of the water in the Pitot tube to a position where it could be easily read. Accordingly, we placed some distance to one side of the Pitot tube a second tube with a square end projecting vertically into the water. Each was connected to a glass tube and these were joined at the top. By creating a partial vacuum the water could be made to rise to a convenient position for reading. When the car was started the water column on the Pitot side rose while the other fell as we expected. But the difference was about 50% more than that given by $\frac{v^2}{2g}$. We soon observed that air was getting into the straight tube and decided to investigate it alone, and found it to give a decided negative pressure. The car was moved in both directions without changing the result, showing that it was not due to any accidental obliquity of the end of the tube.

When we used the Pitot alone without any second pressure tube we found that the constant was in the neighborhood of unity, some of the results being above and some below that figure.

Pitot b is a combined tip, the part to measure the pressure ending in a hole at each side. This was tried in the same way and found to give a vacuum about one-fifth as great as the straight tube.

We later tried the straight tube and the pressure part of b in a jet and found that here where there is perfect freedom of motion laterally and consequently no change in the magnitude of the velocity, there is no pressure whatever. We think it probable that some of the discrepancies in the use of Pitot-meters may be due to failure to get the true static pressure, as has been pointed out by other observers, rather than in any error in the Pitot itself.

[4] W. B. Gregory, Trans. Am. Soc. M. E., December, 1903.

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